METALLURGIA

THE BRITISH JOURNAL OF METALS

Vol. 60 No. 357 JULY, 1959 Monthly: Two Shillings and Sixpence

HALE

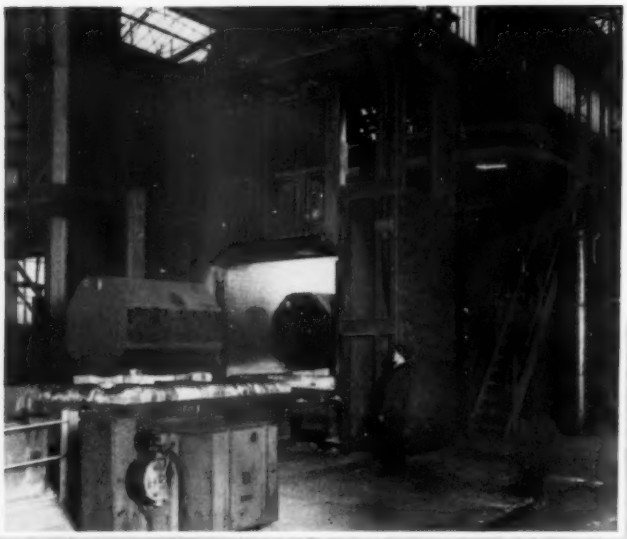
Malleable Iron

CASTINGS

Specified by the leading Industries in Great Britain

HALE & HALE [TIPTON] LIMITED DUDLEY PORT Staffs

GRAMS: 'HALEFO' TIPTON. PHONES: TIPTON 1671/5

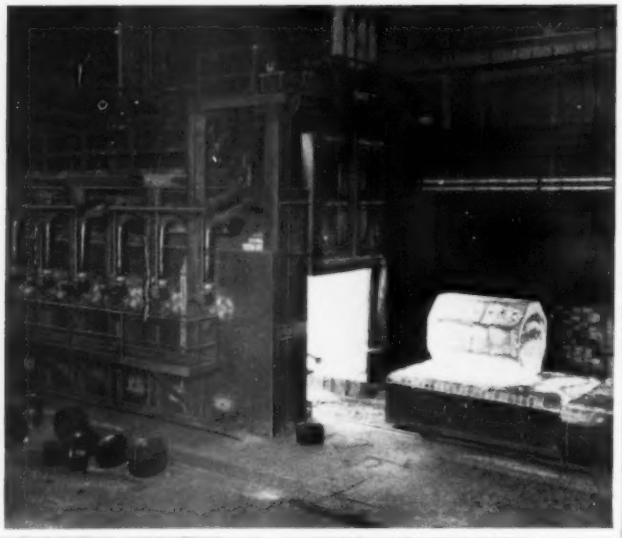


CONTINUOUS BOGIE RE-HEATING FURNACES

PRIEST

We specialise in the design and construction of :—

- Open Hearth Furnaces
- Soaking Pits of all types
- Continuous Multi-zone Bloom and Slab Re-heating Furnaces
- Continuous Bogie type Ingot and Slab Heating Furnaces
- Furnaces for Aluminium Melting, Coil Annealing and Slab Re-heating
- Forge and Heat Treatment Furnaces
- Stress Relieving Furnaces
- Shipyard Plate and Bar Furnaces
- Modern Lime Burning Kilns

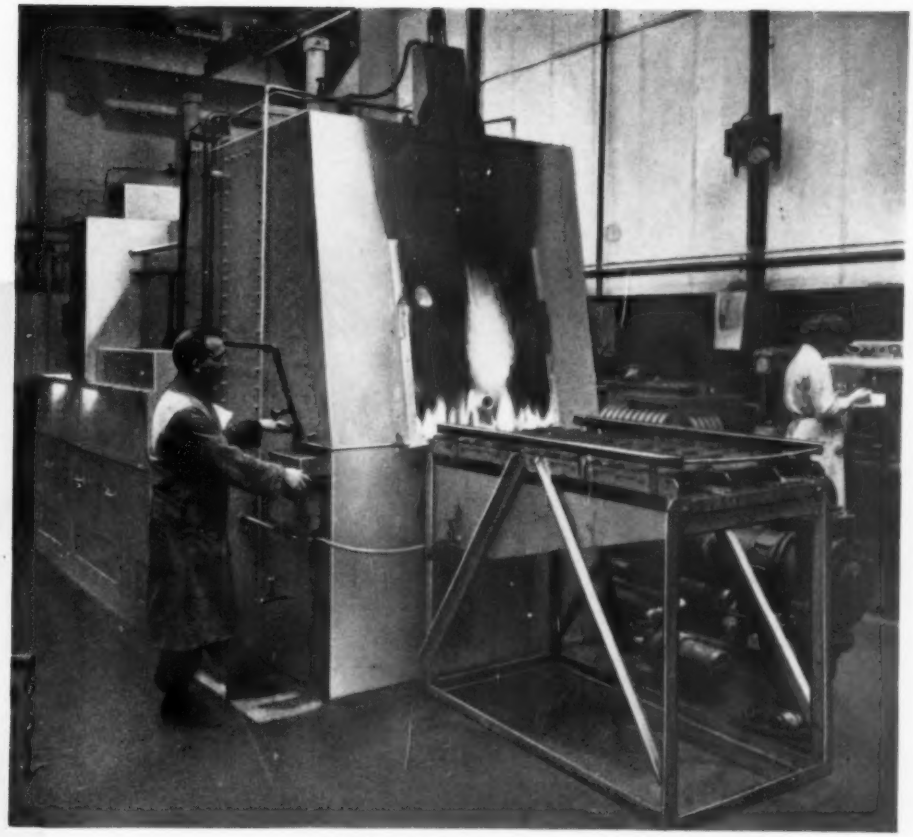


The illustrations are of the charging and discharging end of a Town's Gas Fired Furnace installed for The Chesterfield Tube Co., Ltd.
This unit is for heating billets prior to piercing and is also suitable for heat treating miscellaneous items in the soaking section.

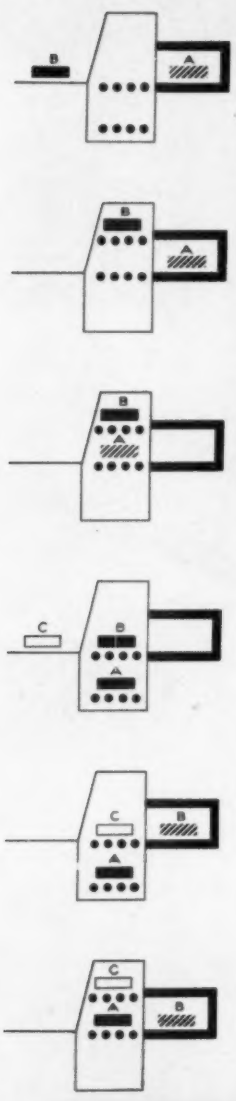
PRIEST FURNACES LIMITED · LONGLANDS · MIDDLESBROUGH
also at TELEGRAPH BUILDINGS HIGH STREET SHEFFIELD

PRIEST
The last word in Furnace design

F.135



Completely mechanised, straight-through "ACE" furnace by Wild-Barfield. (Courtesy G. W. King Ltd., Stevenage, Herts.)



WILD BARFIELD 'ACE' sealed quench furnaces

- VERSATILE IN APPLICATION. Carbonitriding, Clean Gas Carburising, Clean Hardening and Normalising
- TROUBLE-FREE OPERATION. Electric radiant tube elements
- CENTRAL CONTROL CUBICLE. All doors and quench lift hydraulically operated
- RANGE OF SIZES. Covers all normal requirements

ELECTRIC WILD BARFIELD FURNACES

FOR ALL HEAT-TREATMENT PURPOSES

WILD-BARFIELD ELECTRIC FURNACES LIMITED

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WB66

When you order or enquire for carburizing boxes from Thompson L'Hospied you are not left in peace—unless you have given us full particulars of the conditions in which they are to be used. We produce all our Heat-resisting castings from *exactly the right alloy*, so that they'll do a fine job—and do it longer—in even the fiercest heat.

That's where our long experience with the Furnace Industry benefits customers—they use us as an advice bureau—and we like it ! Our cast Nickel Chrome carburizing boxes are in constant use in heat-treatment plants throughout the country. Why not ask a representative to call on you ?

Thompson PIONEERS OF T'H HEAT RESISTING CASTINGS **L'Hospied**

A Member of the Incandescent Group

THOMPSON L'HOSPIED & CO. LTD., STOURBRIDGE

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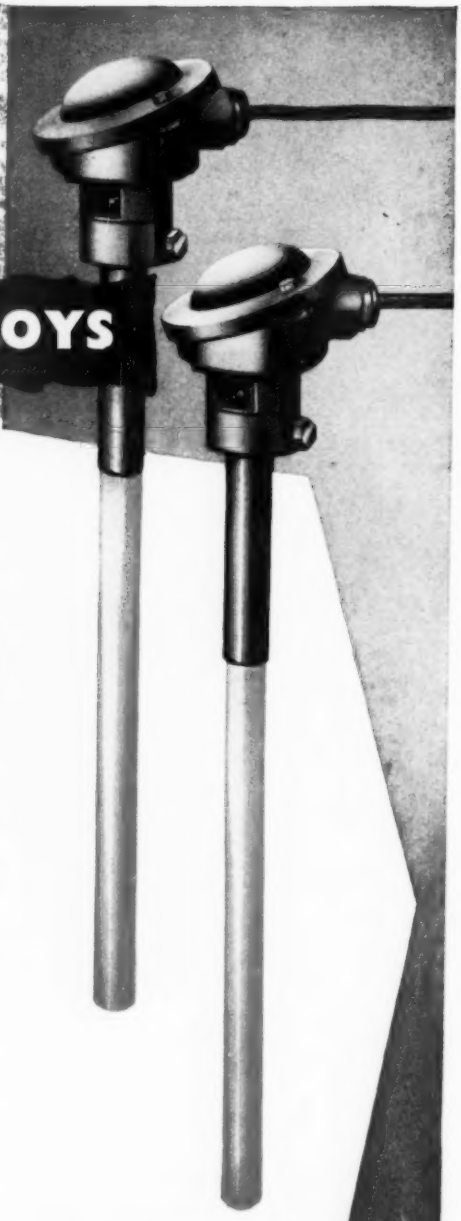
SMETHWICK DROP FORGINGS
MASTERS OF THEIR TRADE
SMETHWICK DROP FORGINGS LTD · SMETHWICK & KIDDERMINSTER

High Temperature

THERMOCOUPLE ALLOYS



"Ni-Cr (plus) v/s Ni-Al (minus)"

Conforming to B.S. 1827:1952

The Thermo-electric properties of the Nickel-Chromium/Nickel-Aluminium Alloys "Ni-Cr(Plus)" and "Ni-Al (Minus)", are in strict conformity with those stated in the American National Bureau of Standards Circular 561, and British Standard Institution Reference Tables for Thermocouples, B.S. 1827:1952.

For Compensating Cables and Extension Leads in Civil and Military Aircraft, "Ni-Cr(Plus)"/"Ni-Al(Minus)" Wires have Ministry of Supply (Air) type approval, for Cables manufactured to Specifications EL. 1705 and 1632.

LOW TEMPERATURE THERMOCOUPLE WIRES:—
CONSTANTAN v PURE IRON
CONSTANTAN v H.C. COPPER

We manufacture a special quality of Thermocouple iron and are able to supply matched wires in the Iron v Constantan combination to meet customers' varied Thermal-EMF requirements. Furthermore, and of infinitely greater importance, we are able to guarantee the reproducibility of those thermo-electric properties.

When ordering Compensating Leads from your usual supplier, for greater accuracy specify: "Thermocouple Wires made by A. C. Scott & Co. Ltd., preferred".

A. C. SCOTT & COMPANY LIMITED

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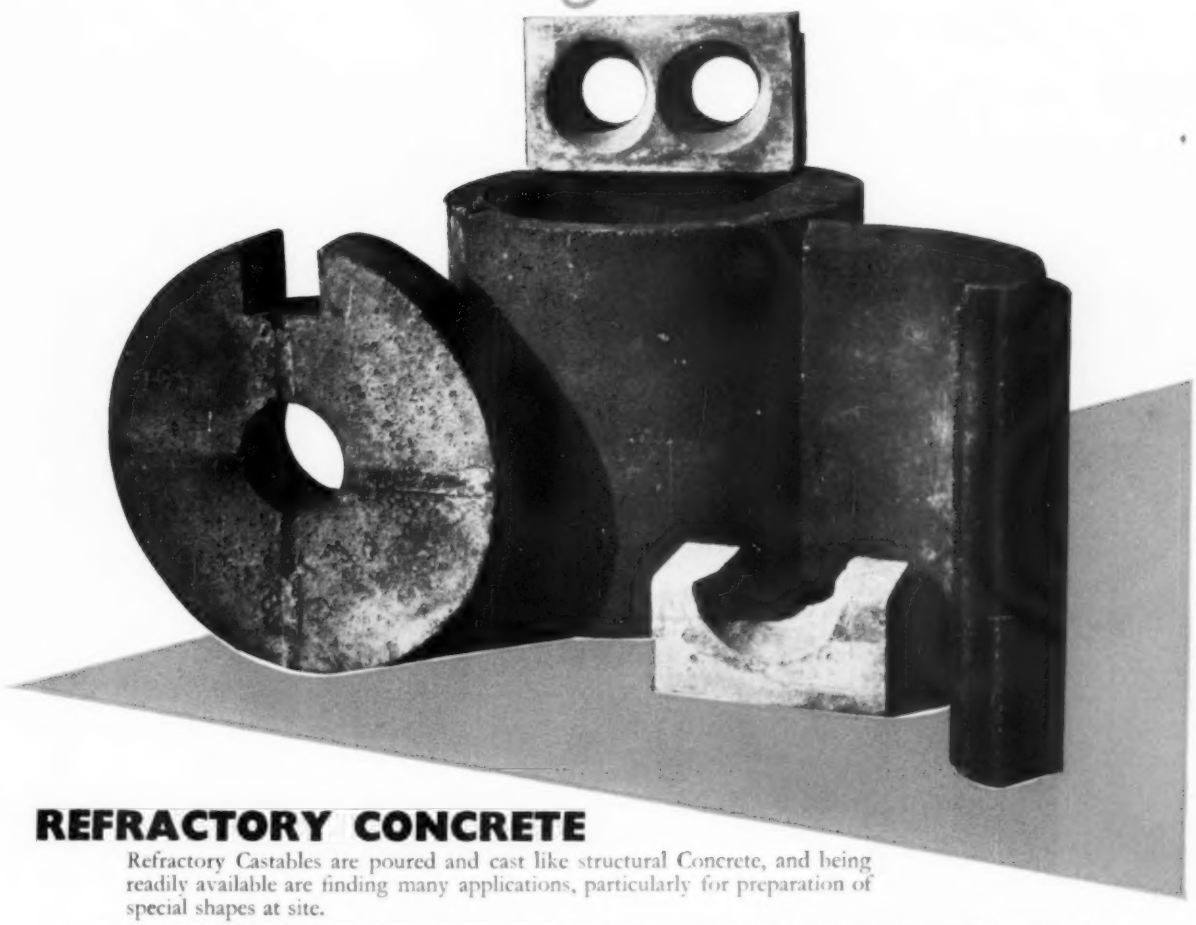
STEIN *Refractories*



REFRACTORY CONCRETE

Refractory Castables are poured and cast like structural Concrete, and being readily available are finding many applications, particularly for preparation of special shapes at site.

	HOW SUPPLIED	REFRACTORINESS	TYPE OF SETTING	THERMAL HARDENING TEMPERATURE	MAXIMUM TEMPERATURE OF USE	lbs./Cu. Ft.
Stein Refractory Concrete	Dry	1420°C	Hydraulic	1200°C	1350°C	120
Stein Super Refractory Concrete No. 16	Dry	+1750°C	Hydraulic	1200°C	1600°C	160
No. 17	Dry	+1750°C	Hydraulic	1200°C	1700°C	160
No. 18	Dry	+1750°C	Hydraulic	1200°C	1800°C	160
Stein Chrome Concrete	Dry	+1750°C	Hydraulic	1200°C	1500°C	180

Use our advisory service based on 70 years experience in the refractory field—it can improve your furnace efficiency. For further information write, phone or call:

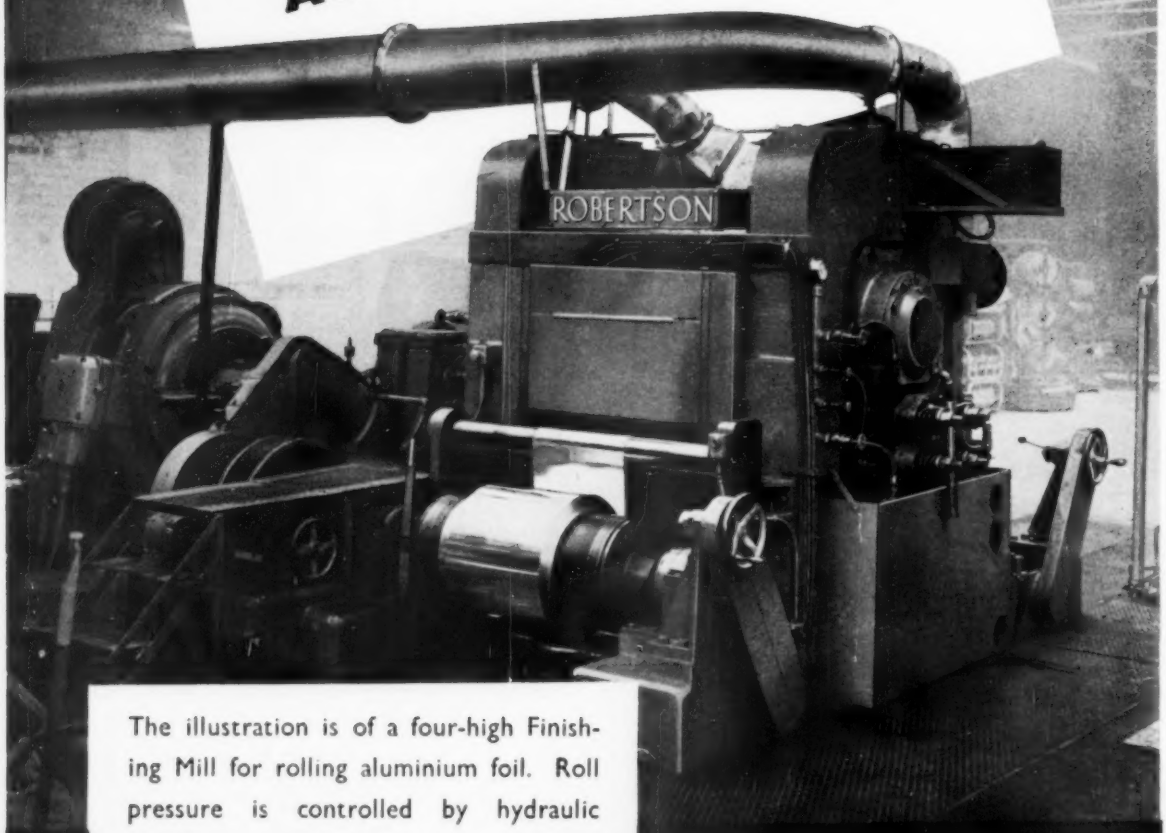
JOHN G. STEIN & CO. LTD. Bonnybridge, Scotland

TEL: BANKNOCK 255 (4 LINES)

ROBERTSON

Builders of

ROLLING MILLS
(HOT · COLD)
FOR FERROUS AND NON-FERROUS METALS, AUXILIARY EQUIPMENT ETC.



The illustration is of a four-high Finishing Mill for rolling aluminium foil. Roll pressure is controlled by hydraulic cylinders. Maximum rolling speed 2,500 ft/min.

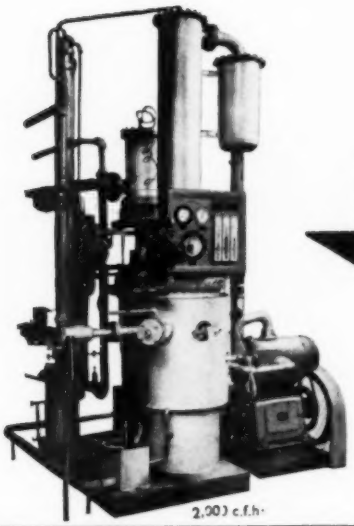
Photograph by courtesy of Venesta Ltd., London, E.16.

W. H. A. ROBERTSON & CO. LTD., BEDFORD, ENGLAND

LICENSEES FOR THE BUILDING OF SENDZIMIR COLD REDUCTION MILLS & PLANETARY HOT MILLS

Gibbons Mahler-v-Linde

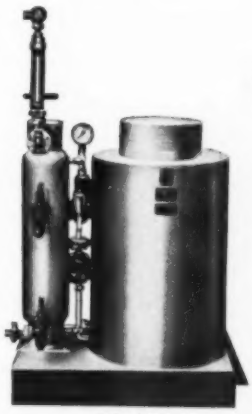
Atmosphere generators with a wide range of applications in many industries. In the metal industry for bright annealing, brazing, sintering, gas carburising, bright hardening, etc.



2,000 c.f.h.

GmvL Ammonia Cracker

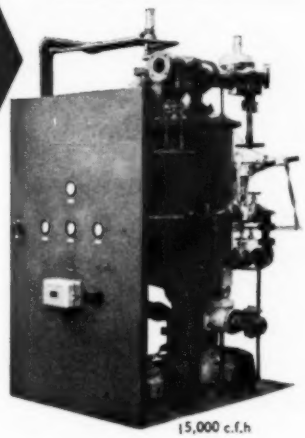
For bright treatment of stainless acid resisting and heat resisting steels, and for brazing and sintering generally.



150 c.f.h.

Gibbons Sub-X Inert Gas Generator

A highly efficient and compact producer of inert gas, operating on standard gaseous fuels and distillate grades of fuel oils.



15,000 c.f.h

G.A.A. Endothermic Generator

For gas carburising, dry cyanide treatment, etc. Automatic response to variations in demand while maintaining correct gas/air ratio.

500 c.f.h.

Write for further details to :

GIBBONS APPLIED ATMOSPHERES LIMITED

A SUBSIDIARY COMPANY OF GIBBONS BROS. LTD.

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KIP LIGHTWEIGHT INSULATING REFRACTORIES are playing an ever increasing part in the expansion of British industry. In many different types of furnaces, kilns and boilers, KIP INSULATING PRODUCTS ensure that heat is utilised efficiently and economically.

Continuous research at our works and in co-operation with industrial and technical associations and individual firms is resulting in new uses being discovered for lightweight refractories and the development of new types of products to increase furnace efficiency.

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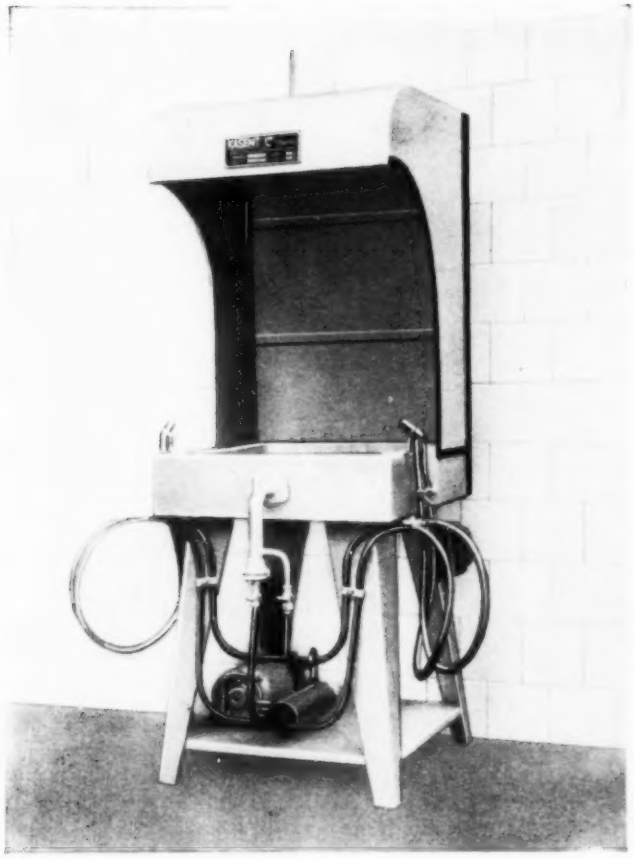


GAS BLAST COMBINED FORGE AND BRAZING HEARTH

Complete with Motor Driven Positive Air Blower, two Gas Blast Blow Pipes and one Gas Blast Burner. Suitable for Tube bending up to 1 in. diameter.

Size of Hearth, 20 in. × 20 in. × 4 in.

Gas Consumption, 200 cu. ft. per hour maximum.

NATURAL DRAUGHT GAS FIRED SALT BATH SUITABLE FOR CYANIDE OR NEUTRAL SALTS

Suitable for temperatures up to 900° C.

Obtainable in the following sizes :
8 in. dia. × 8 in. deep, gas consumption 300 cu. ft./hr.
8 in. dia. × 10 in. deep, gas consumption 350 cu. ft./hr.
10 in. dia. × 12 in. deep, gas consumption 400 cu. ft./hr.

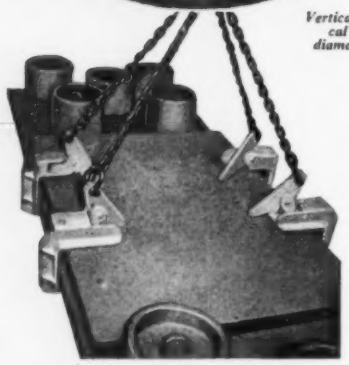
Time to heat up—1½ hours.

Manufactured by

KASENIT LTD

7, HOLYROOD STREET · BERMONDSEY · LONDON, S.E.1

B.E.R.L Specialised Lifting Tackle



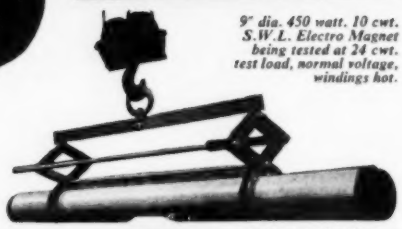
Type NRSA Plate Lifting Sling with common lifting ring with self aligning swivelling clamps. Range 1 to 10 tons.

Vertical cylindrical specified diameter lifting device.

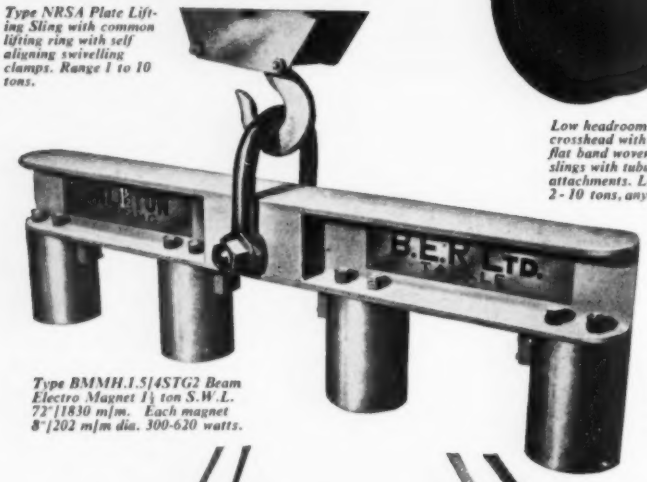
Horizontal cylindrical specified diameter lifting device, also supplied with special clamp faces for handling ground diameters.

Low headroom all steel crosshead with pair of flat band woven wire slings with tubular end attachments. Load range 2 - 10 tons, any diameter.

9" dia. 450 watt. 10 cwt. S.W.L. Electro Magnet being tested at 24 cwt. test load, normal voltage, windings hot.

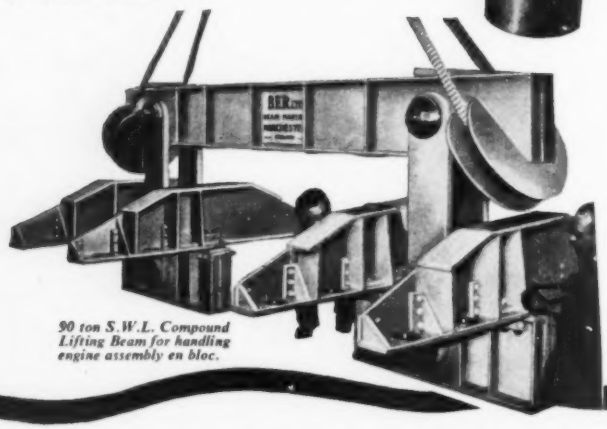


Rubber lined split clamp lifting device for hot semi-plastic loads.



Type BMMH.1.5/4STG2 Beam Electro Magnet 1½ ton S.W.L. 72"/1830 m/m. Each magnet 8"/202 m/m dia. 300-620 watts.

Ingot lifting device for lead or copper etc., to any size and rating required.



90 ton S.W.L. Compound Lifting Beam for handling engine assembly en bloc.

The BERL service is offered to all users of lifting tackle and illustrated above are some of the lifting devices from our extensive range. When dealing with your load raising problems remember BERL hold the answers.

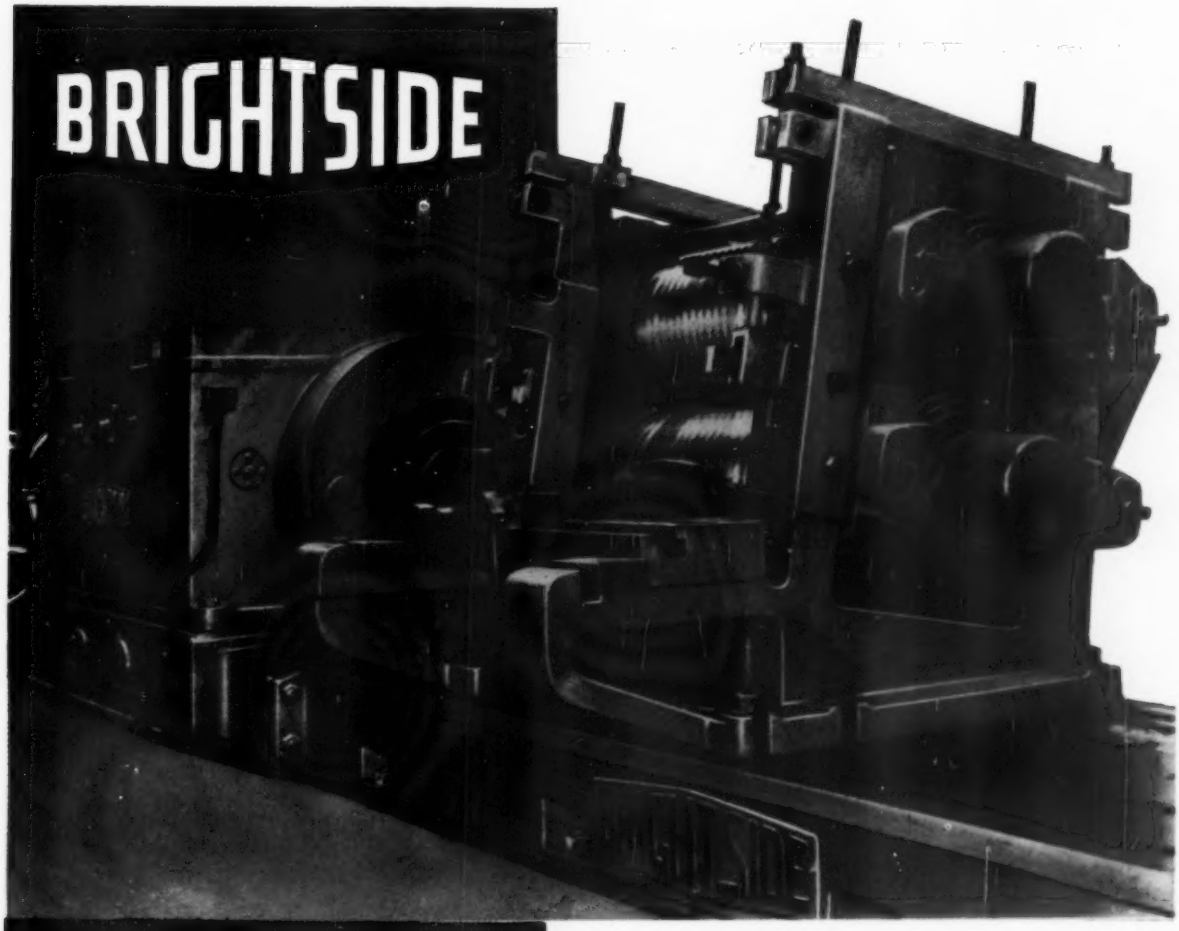
B.E.R.L

Better Equipment for Raising Loads

BRITISH ELECTRICAL REPAIRS LIMITED, EMPIRE HOUSE, CHARLOTTE ST., MANCHESTER 1

dm BER. 89

BRIGHTSIDE



HOT AND COLD ROLLING MILLS.

ROLLS FOR HOT AND COLD ROLLING.

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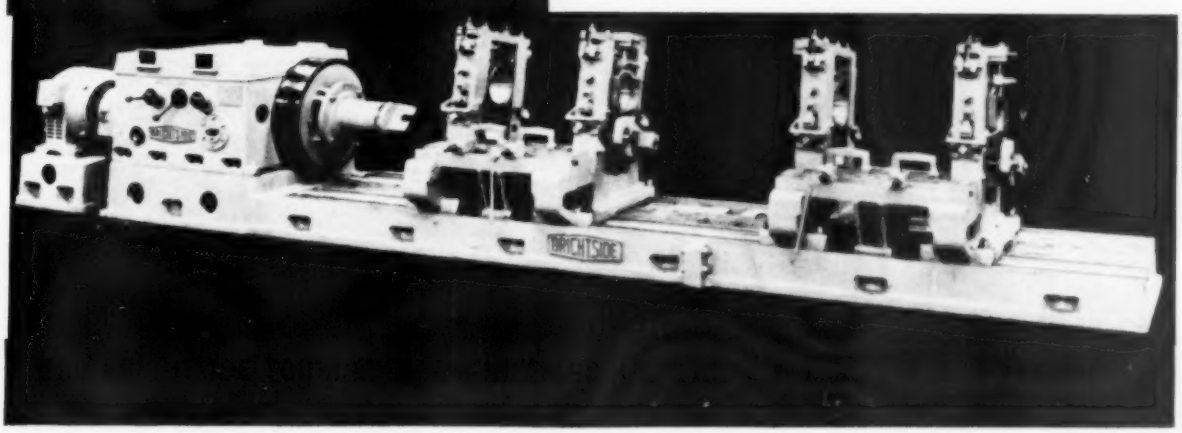
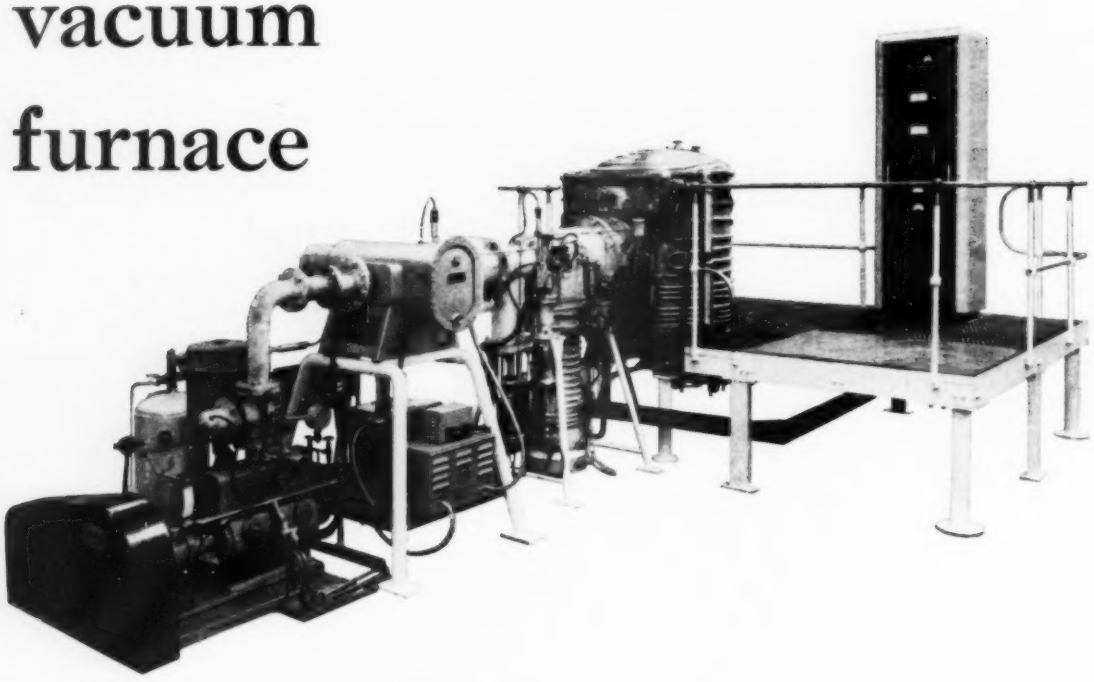
HOT SAWS AND REELERS.

STEELWORKS PLANT AND AUXILIARIES.



high vacuum furnace



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Induction Heating.

Roots Type Blower Pump fitted, to enable clearance of fast outgassing from the metals being processed. A Servo-controlled throttle valve fitted, to maintain a pre-determined pressure in the vacuum furnace chamber.

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VIA-VAC
SERVICE TO INDUSTRY

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Heating Rods for High Temperatures

The high reputation of SILIT Heating Rods
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They are remarkable for their limited amount of "ageing"
which is amply covered by a voltage reserve
of only 40% for temperatures up to 1500°C.
A salient feature of the SILIT Heating Rods is that butt joints
between the glowing portion and the connecting ends are avoided.
The thickened ends are formed by tightly fitting sleeves
made of the same material as the rods.

A wide range of Silit Rods of equal diameter throughout can also be supplied, diameters ranging from $\frac{1}{16}$"- $1\frac{3}{4}$".

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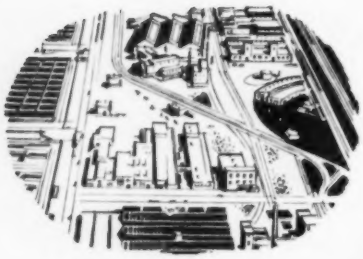

Mining, shipping, the production of hydro-electric power, the smelting of primary aluminium and the production of semi-fabricated products—these are the basic activities of the Aluminium Limited Group of Companies.
But industry expects more from us than aluminium—industry expects service and it is service that we offer. Service in terms of research, technical information and advice.
Laboratory and field research is the responsibility of a subsidiary company of Aluminium Limited—Aluminium Laboratories Limited. This company has extensive research facilities in Canada, England and Switzerland. The head office at Montreal co-ordinates all exploration and geological surveys and develops equipment and plant for all phases of aluminium production.

than

The Laboratory at Arvida, Quebec specialises in problems associated with ore extraction and smelting. The laboratories at Kingston, Ontario, and Banbury, England, are engaged in intensive research into the techniques of fabrication and the use of aluminium. The fundamentals of design are the concern of Aluminium Laboratories Limited at Geneva.

meets the eye

To research add information. The Aluminium Limited organisation has available nearly 900 technical publications. These are published in many different languages including Arabic, Japanese and Finnish.
Over seventeen films with versions in English, French, Spanish and German are available. These provide invaluable background and technical information for the aluminium industry.
Aluminium is our business. We back every pound we sell with service, research and information.

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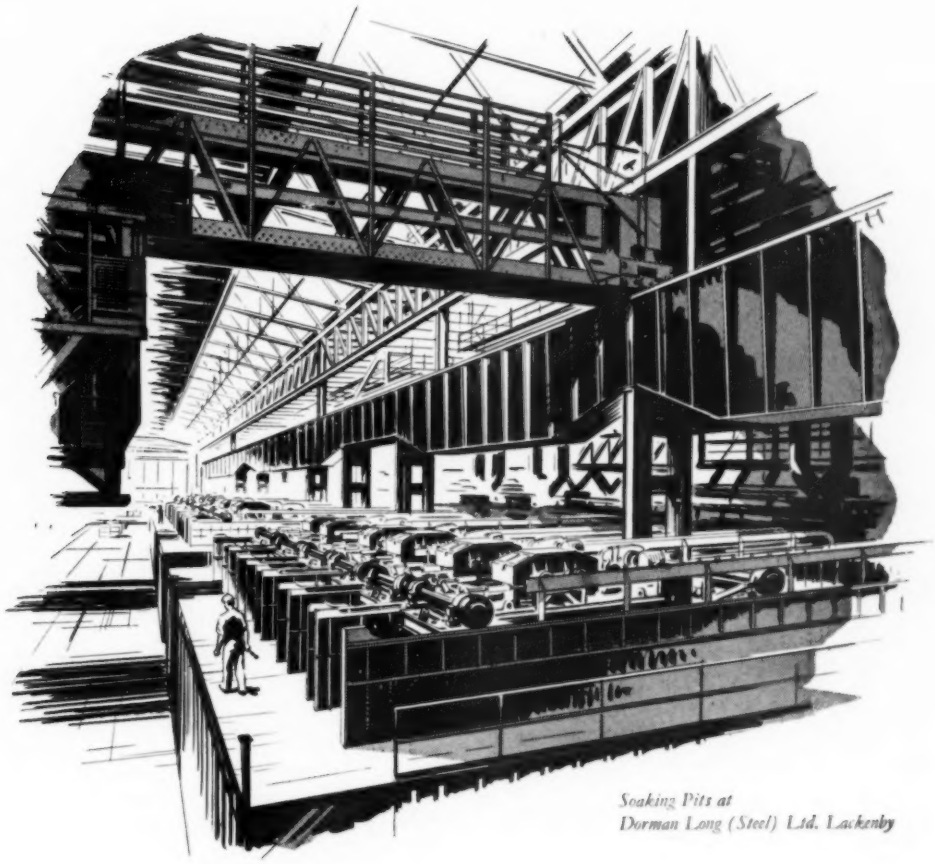

Soaking Pits at
Dorman Long (Steel) Ltd. Lackenby

serving the

STEEL INDUSTRY

"Surface" One-way fired Soaking Pits

The continuing confidence in S & A Furnace Engineering is given outstanding emphasis by the number of new installations and repeat orders of their one-way fired soaking pits in Britain's Steel Mills.

John Lysaght's Scunthorpe Works Ltd. Round Oak Steel Works Ltd. Consett Iron Co. Ltd. Dorman Long (Steel) Ltd., Redcar. Stewarts and Lloyds Ltd. Steel, Peech & Tozer. The Briton Ferry Steel Co. Ltd. Dorman Long (Steel) Ltd., Lackenby. Workington Iron a Steel Co., (Branch of The United Steel Companies Ltd.). These constitute a truly impressive list.

AND NOW The South Durham Plate Mill scheme and the 1st stage of Colville's Ravenscraig Mill.

S & A STEIN & ATKINSON LTD. LONDON

BRIGHT STEEL
ROUNDS · HEXAGONS ·
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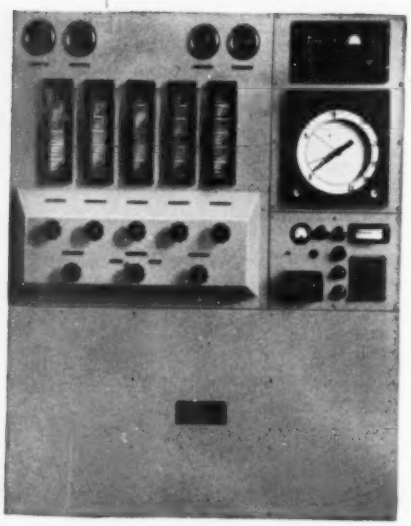
BAKER PLATINUM

G.N.L Nitroneal Generator

for producing ***PURE NITROGEN***
with a controllable hydrogen content



The Nitroneal Generator produces pure nitrogen with a controllable hydrogen content by reacting ammonia with air in the presence of a special Baker catalyst. The apparatus generates a gas completely free of oxygen, consisting only of nitrogen, hydrogen and water vapour. The hydrogen content can be varied at will to meet changing requirements and can be maintained at any desired percentage between 0.5% and 25% within close tolerances. This flexibility permits the use of the appropriate gas for any material or process at the lowest cost.

IMPORTANT ADVANTAGES are ECONOMY · HIGH PURITY SAFETY · FULLY AUTOMATIC · ADJUSTABLE GAS MIXTURE UNIFORM ANALYSIS · POWER ECONOMY · LOW DEW POINT

Write for leaflet giving full details. Technical representatives available for consultation and advice.

ENGELHARD INDUSTRIES, LTD. BAKER PLATINUM DIVISION
52 HIGH HOLBORN, LONDON, W.C.1. *Telephone: CHAncery 8711*

Photograph by Courtesy of
Geo. Tucker Eyelet Co. Ltd., Birmingham

one, two, buckle my shoe . . .

Of course, the buckles have changed to eyelets, but the rhyme holds good, for there are two INCANDESCENT roller hearth furnaces in this factory, bright annealing 8 cwt. of steel and brass eyelets an hour.

INCANDESCENT roller hearth furnaces use centrifugally cast nickel-chromium alloy rollers for temperatures up to 1,000°C., and sillimanite compression rollers for use at higher temperatures. Both are exclusive INCANDESCENT features. Heating is by gas-fired radiant tubes above and below the rollers giving a high rate of heat transfer and uniformity of heating. The protective atmosphere is supplied by INCANDESCENT exothermic gas generators.

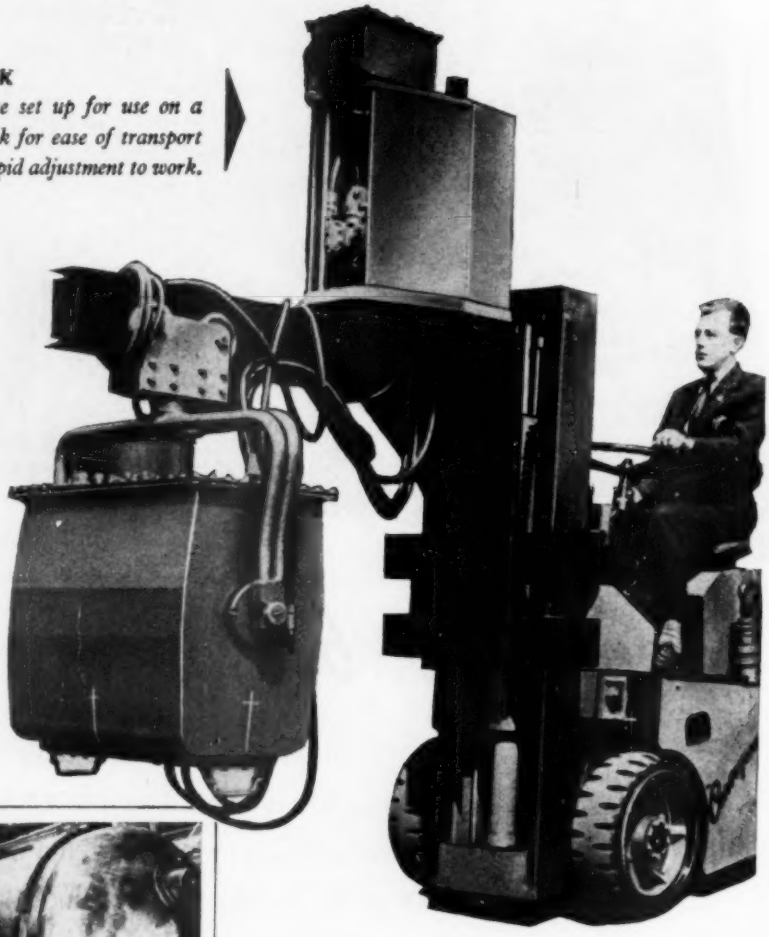
INCANDESCENT

THE INCANDESCENT HEAT CO. LTD. · SMETHWICK · ENGLAND

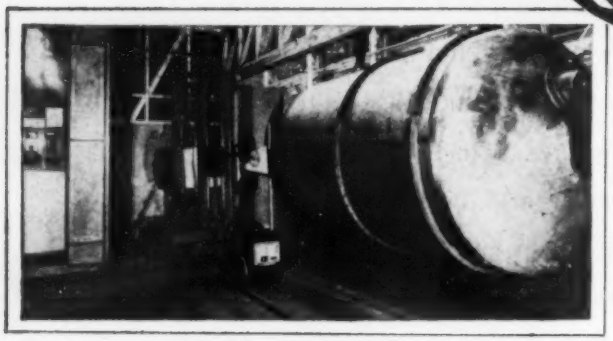
13/2/59

Right to the job with the RAYMAX 250 X-Ray Unit

BY HYDRAULIC LIFT TRUCK
The Raymax 250 is shown here set up for use on a standard 'Conveyancer' lift truck for ease of transport to any part of the plant, and rapid adjustment to work.



The compact design and extreme mobility of the Newton Victor Raymax 250 enables modern non-destructive x-ray testing to be brought to any job either inside or outside the factory. The x-ray tube and all high voltage parts are enclosed in a robust, single-tank design for protection against climatic conditions. Precise and simple control at the point of use combines with a power of penetration sufficient to meet the most exacting weld-testing requirements. A wide variety of mountings is available for use in factory, laboratory or on open constructional sites.



ON FLANGED-WHEEL MOUNTINGS
For pressure vessel testing at the engineering works of Davey, Paxman and Company Limited, the Raymax 250 is carried on track-borne, flanged wheel mountings.

Newton Victor Limited

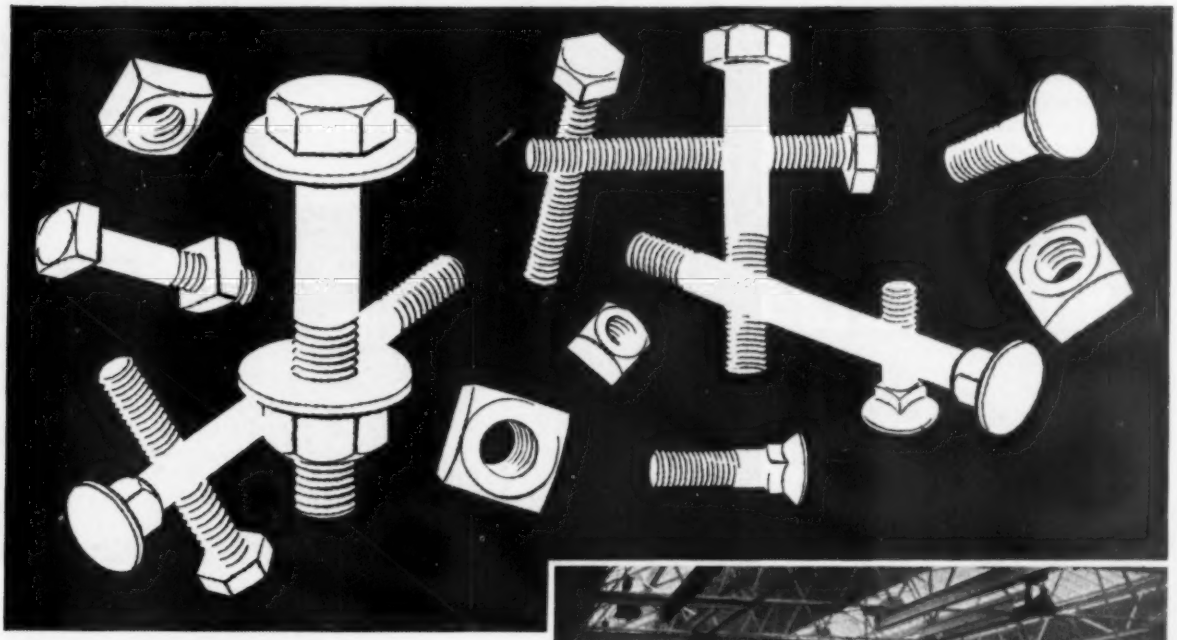
132 LONG ACRE, LONDON, W.C.2.

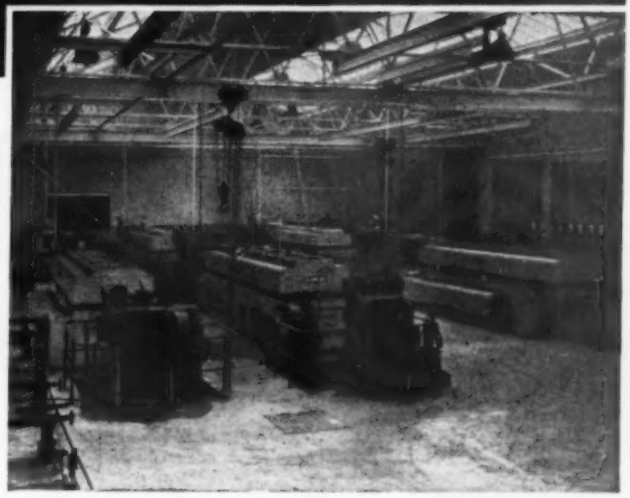
X-RAY DEPARTMENT OF METROPOLITAN-VICKERS ELECTRICAL CO. LTD., TRAFFORD PARK, MANCHESTER 17

An AEI Company

TGA V/809

GKN AND G.W.B.





G.W.B. Hardening & Tempering Furnaces at Guest, Keen and Nettlefolds, Darlaston.

Two sets of initials, both of which stand for reliability. Millions of nuts, bolts, rivets and fasteners of all types leave the Darlaston (Staffs.) works of Guest, Keen & Nettlefolds (Midlands) Limited every week. Accurately made from the best quality materials, heat-treatment plays an important part in ensuring that they conform to the highest specifications.

Among the latest equipment installed by G.W.B. Furnaces Limited are three completely continuous lines of Hardening and Tempering furnaces. Each line comprises: 30 cwts. Loading hopper—De-greaser—Hardening furnace—Continuous quench extractor—Loading hopper—De-greaser—Tempering furnace—Continuous quench extractor. The Tempering units can also be used independently as Hardening furnaces if required. Each furnace has an output of 5/6 cwts. per hour, and the whole installation is served by two men only, one to supervise the general operation and one fork truck driver who, among his other general factory duties, loads the hoppers and conveys the full bins of heat-treated components to the Packing Dept.

"If it's a matter of how to fasten one thing to another, get in touch with GKN." If it's a question of electric heat-treatment or melting equipment, consult G.W.B.

Over 25 years' experience in electric furnace design at your disposal.

GWB

G.W.B. FURNACES LTD.

P.O. BOX4, DIBDALE WORKS, DUDLEY, WORC. *Tel: Dudley 55455 (9 lines)*

Associated with Gibbons Bros. Ltd., and Wild-Barfield Electric Furnaces Ltd.

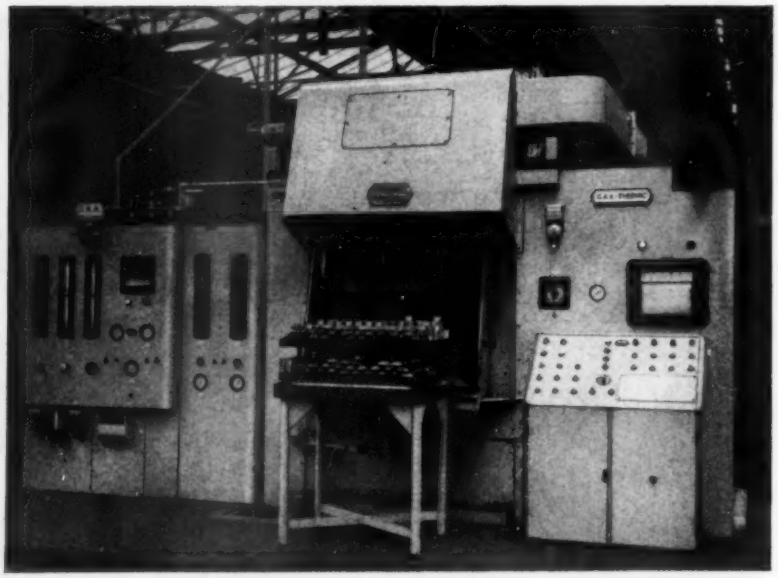
GWB217

Heat Treatment
–Gas Board Demonstrates latest developments.

IN this modern general metals age of ours it seems a far cry to the days when the heat treatment of metals was considered to be a 'black art' and when the closely guarded secrets of the swordmakers and workers in precious metals were handed down from father to son. Today we recognise the value of the comparatively new technology of metallurgy and realise the benefits our civilization receives from the new metallic alloys and from the new plants and methods of processing these alloys which have been developed during the last few decades.

The type of plant we have in mind includes such items as the new heat treatment furnace which the West Midlands Gas Board recently has had installed in its Heat Treatment Service establishment located at Adderley Street, Birmingham 9. This establishment was brought into being by the Birmingham Gas Department more than 40 years ago and the plant has been continually brought up to date. The experience of the metallurgical staff of the 'service' is considerable and this is reflected in the quality of the supervision given to all the heat treatment processes carried out at Adderley Street, as well as in the advice given to consumers concerning the use of gas fired plant. This new item of plant, one of the first of its kind to be installed in the Midlands, is an atmosphere controlled batch-type unit, capable of accepting a total load measuring 3 ft. 0 in. wide, 2 ft. 0 in. deep and 1 ft. 6 in. high, and operating up to temperatures of 950° C. The furnace itself comprises two separate chambers, a hot zone, heated by recuperative gas fired nickel-chrome radiant tubes, placed above and below the work chamber; and a water jacketed discharge vestibule. An oil quench tank is incorporated below this vestibule and both the vestibule door and the inner furnace door are power operated.

Controlled atmospheres, suitable for a wide variety of treatments including clean hardening and annealing, gas carburising and carbonitriding, are supplied from an endothermic generator forming part of the plant. This generator is fired by towns gas but uses propane gas and air for the production of the endothermic gas. Both propane and ammonia enrichment are provided, for use when gas carburising or carbonitriding, and it is possible to vary the 'dew point' of the atmosphere gas in order to provide clean heat treatment of steels over a wide range of specifications.



This Gas-fired furnace of new design for gas carburising and clean heat treatment in controlled atmospheres is a working exhibit at the Board's Heat Treatment Service establishment.

The furnace is operated from a control panel and desk which provides automatic furnace temperature recording control, atmosphere control and push button control of all the power operations attendant upon the charging, discharging and quenching of the furnace load, which thus become automatic operations, each action being indicated by signal lights on the panel. Vertical flow gauges and dial gauges incorporated in the panel complete the instrumentation of the plant, and the panel thus gives the operator an immediate picture of the stage of the process and the state of the plant at any given time.

In order fully to demonstrate this plant to prospective purchasers it is of course necessary to operate it on a commercial heat treatment shop basis and the Board's Heat Treatment Service is open to receive orders for the gas carburising of such items as crown wheels and pinions, gears, cams and cycle components, clean annealing, hardening, and tempering of special die blocks, machined parts and similar items. All this work would be carried out to the requirements of the client concerned, would be supervised by qualified metallurgists, and when necessary would conform to the dictates of any inspection approval.

Industrialists, metallurgists and plant engineers are invited to inspect any of the items of plant at Adderley Street either with a view to installing similar plant at their own works or for the purpose of assessing the usefulness to their own organization of the commercial heat treatment facilities provided by the 'Service'.

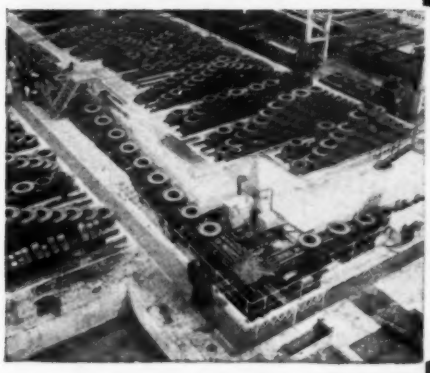
This is an advertisement by the West Midlands Gas Board.

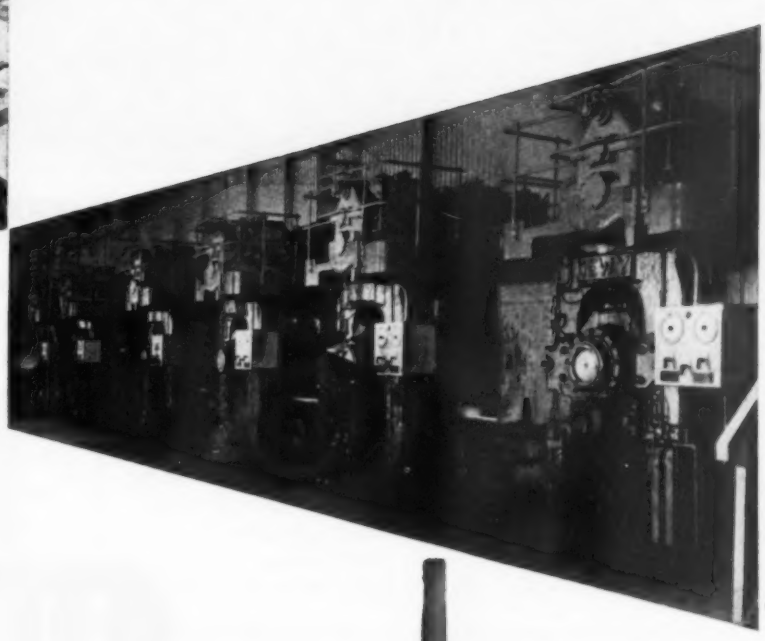
STEEL, PEECH & TOZER

A Branch of The United Steel Companies Limited

P.O. BOX 50, THE ICKLES, ROTHERHAM, YORKSHIRE

HOT ROLLED STEEL STRIP





The new Brinsworth mill hot rolls steel strip

—in widths from 6 to 18 inches

—thicknesses from ·042" to ·250" varying according to width

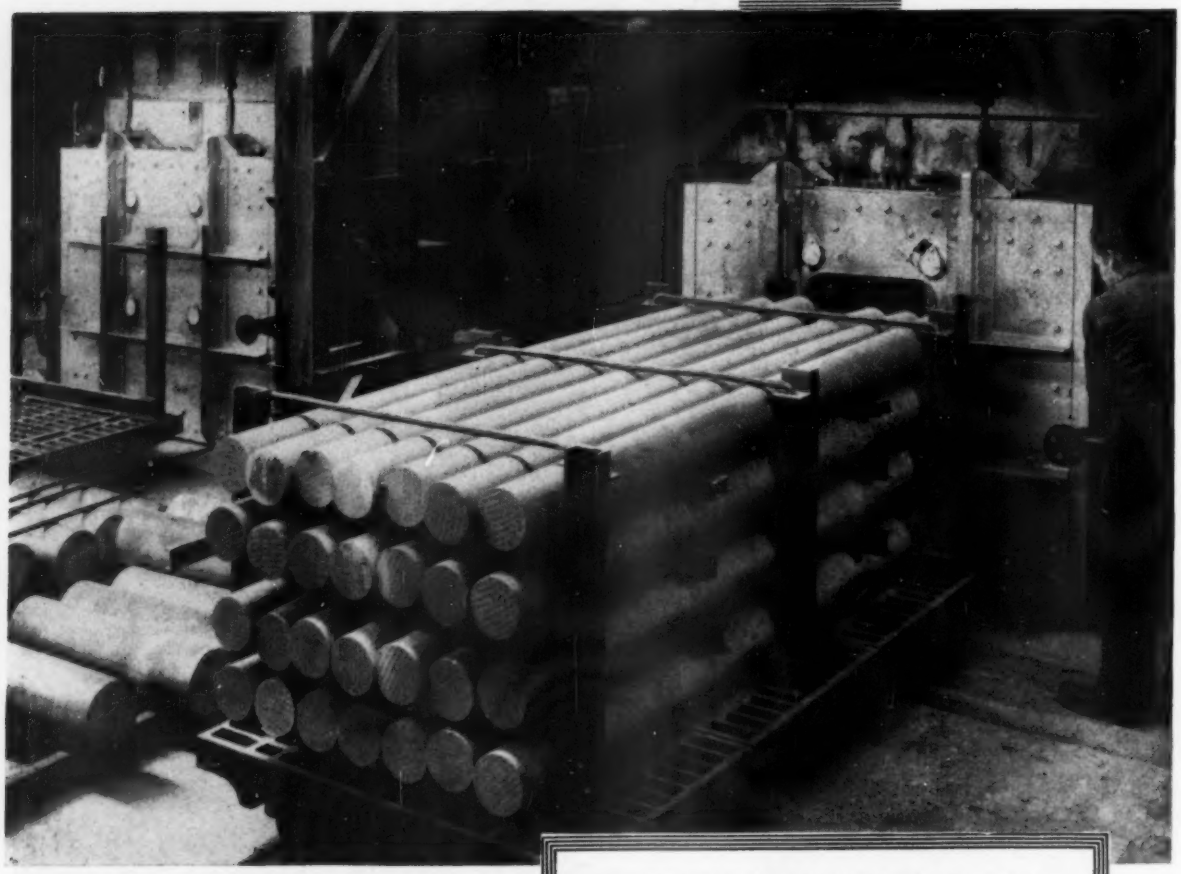
—qualities which include mild steels, medium and high carbon steels, "Fortiweld," "Cor-Ten" and other special steels.

The Templeborough Strip Mill produces hot rolled strip

—in widths up to 6 inches

—thicknesses from ·030" to ·192" varying according to width.

SP 218



By kind permission
Messrs. Reynolds T. I. Aluminium Co. Ltd.

TWO DIRECT GAS-FIRED CONVECTION TYPE FURNACES WITH HIGH SPEED RECIRCULATING FANS FOR HOMOGENISING ALUMINIUM BILLETS

GIBBONS

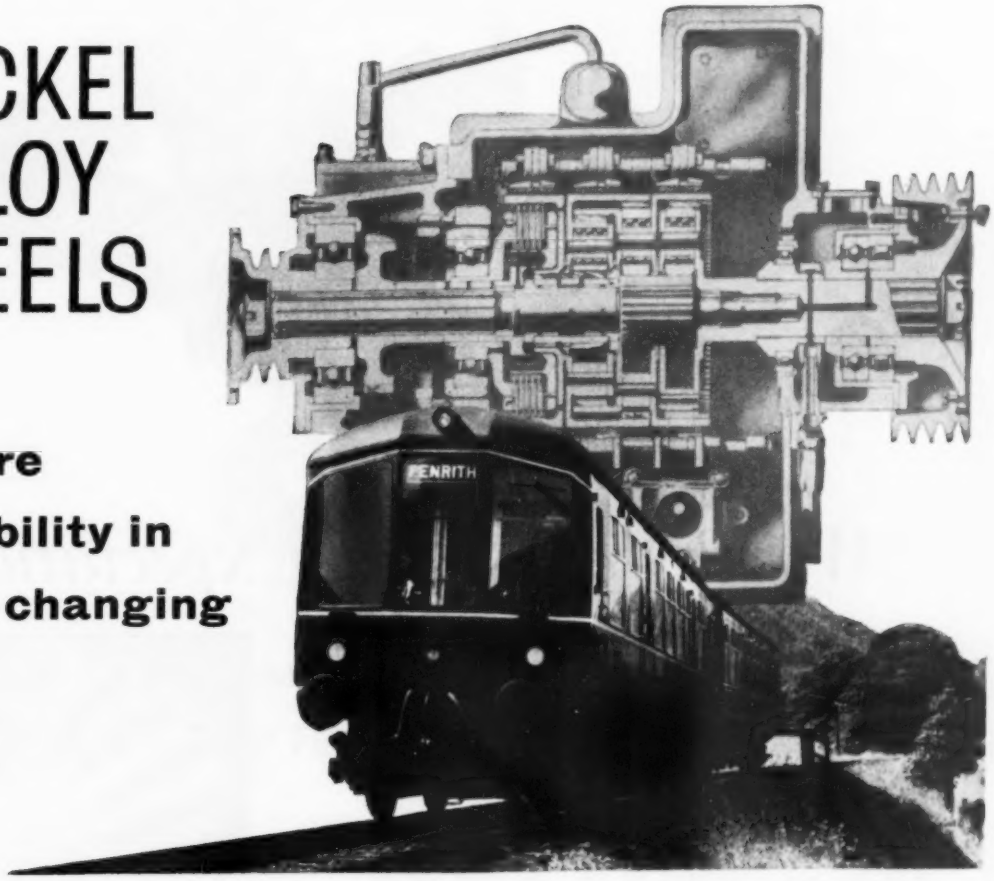
GIBBONS BROTHERS LTD

P.O. BOX 19, DIBDALE, DUDLEY, WORCS

TELEGRAMS: "GIBBONS, DUDLEY" TELEPHONE: DUDLEY 55141 (P.B.X.)

NICKEL ALLOY STEELS

ensure reliability in gear changing



The self-changing gear box, produced by Self-Changing Gears Ltd., Coventry, is standard on road, rail and water transport in many lands, and notably on London's buses.

This famous unit, in both its pre-selector and fully automatic versions, incorporates a range of nickel alloy steels. Although there is no direct mechanical operation of the gears in the normal way, heavy train, truck and bus operation inevitably imposes severe stresses upon the gears and to withstand these stresses most of the operating mechanism in the 'Wilson' box is made from nickel alloy steels, including the 3 per cent nickel-chromium-molybdenum EN 36 case-hardening steel.

TYPICAL CORE MECHANICAL PROPERTIES OF

EN36

SIZE	HEAT TREATMENT	MAXIMUM STRESS t.s.i.	ELONGATION per cent	IZOD ft. lb.
1½" dia.	Oil quenched 780°C.	72·0	19	69
2½" dia.	Oil quenched 860°C. Oil quenched 780°C.	62·7	19	67
3" dia.	Oil quenched 860°C. Oil quenched 780°C.	59·7	22	72

The benefits to be gained from the more highly alloyed case-hardening nickel steels, such as EN 33, EN 34, EN 36 and EN 39 include ease of heat-treatment, minimisation of processing distortion, and general reliability.

Send for 'The Mechanical Properties of Nickel Alloy Steels' ▶

YGA 21/2R

MOND NICKEL

THE MOND NICKEL COMPANY LIMITED, THAMES HOUSE, MILLBANK, LONDON, S.W.1

"Worthy ends and Expectations"

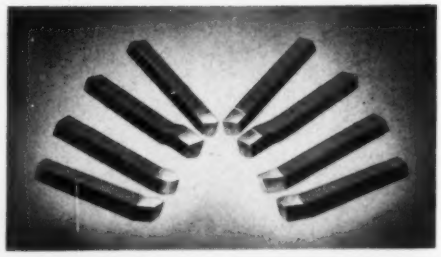
" ——**when a man hath obtained worthy ends and expectations,**" *suggested Bacon, he may then rest on his laurels.*

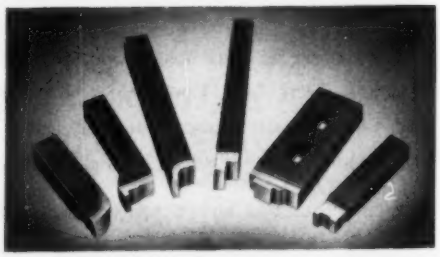
With Superweld Tools you certainly do obtain a worthy end—a substantial cutting end of Stag Major super high speed steel, electrically fuse-butt-welded to a high grade steel shank ; plenty of usable cutting metal at a fraction of the cost of a solid tool.

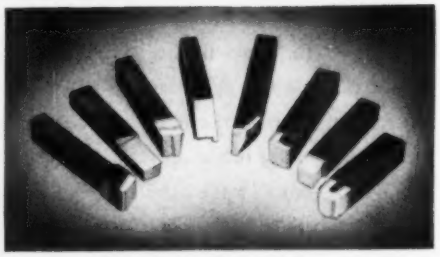
As for expectations, you can look forward to an exceptionally long life from Superweld Tools, which are supplied ready hardened to give maximum cutting efficiency of which the fine tool steel is capable.

Superweld Tools are especially advantageous as precision form tools where little regrinding to shape is possible and the economy over a tool of solid high speed steel is obvious.

We have in stock over 65,000 Stag Major Superweld Tools in a great variety of standard shapes and sizes, or can supply tools to your own specification.







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SUPERWELD TOOLS

Edgar Allen & Co. Limited
IMPERIAL STEEL WORKS · SHEFFIELD · 9

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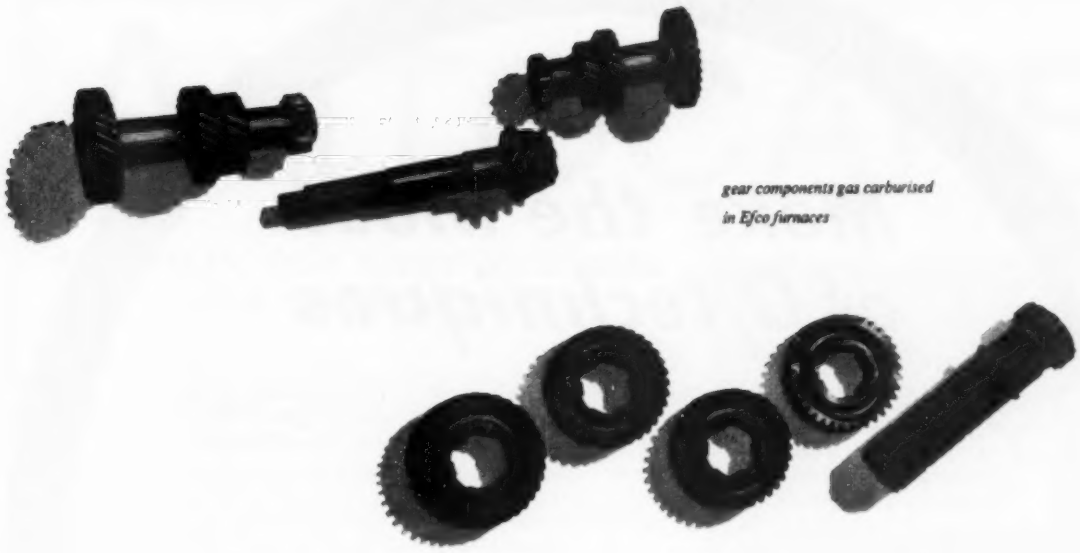
Address .....



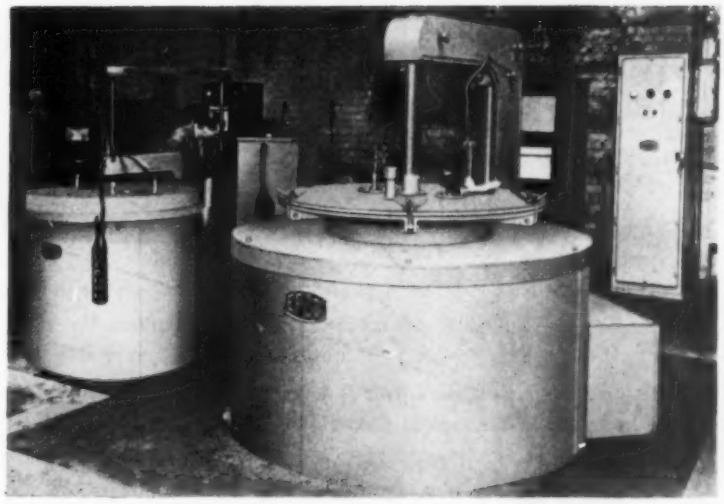
gear components gas carburised in Efco furnaces

Automobile gear components Carburised in EFCO Furnaces

Austin, Crossley, Ford, Jaguar and other leading firms in the motor industry use Efco furnaces for hardening, gas carburising or carbonitriding gear components.

Pit type, horizontal GVRT type, shaker hearth, or continuous furnaces are offered. The heating may be gas-fired radiant tube, or electrical—including the revolutionary Corrtherm element—according to type. Either endothermic gas or hydrocarbon drip feed can be supplied for the carburising or carbonitriding gas.

The furnace and cooling chamber on the right are installed at Crossley Motors Ltd. A standard Efco G.C.V.4 furnace, rated at 100 kW, its charge basket dimensions are 24 in. diam. by 54 in. deep. The carburising gas is obtained from a hydrocarbon drip fee 1 unit.



EFCO

Let us send you the Efco Carburising & Carbonitriding Catalogue No. R.21

ELECTRIC RESISTANCE FURNACE CO. LTD., NETHERBY, QUEENS ROAD. WEYBRIDGE, SURREY

Telephone Weybridge 3891 . . . *Associated with Electro-Chemical Engineering Co. Ltd.*

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Make the most of O_2 techniques

Imagine Hamlet without the Ghost! Difficult, isn't it? Well to some extent it's as difficult to contemplate operating the new oxygen steelmaking techniques without refractories researched and designed for this job. Through its extensive Research Department, General Refractories have developed new refractories to deal with these many new problems raised by oxygen steelmaking. For instance, Ferroclad '100' EE reduces wall lining wear in Open Hearth and Electric Steel Units — Ferroclad '30' EE and Densyl give increased roof life in Open Hearth furnaces — Spinella 'R2' offers exceptional advantages in full open hearth roofs — Spinella 'A' and Sillmax have solved problems in regenerator roofs and checker filling—GR 341 Dolomite bricks provide perfect linings for L.D., Kaldo and Rotor convertors, ladles, etc.

GR Technical Service Department is available for consultation by users in the selection and application of these and other refractories.

Everything in GR Refractories

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AUTOCARB

AUTOMATIC DEW POINT RECORDERS AND CONTROLLERS

Autocarb systems automatically adjust the flow of air or enriching hydrocarbon to the furnace or generator in direct response to the dew point of the atmosphere.

Specified conditions are automatically maintained.

Autocarb systems are simple compact units which indicate, record and control the dew point of gas atmospheres in continuous or batch furnaces and atmosphere generators. They can control dew points to within plus or minus two degrees.

Recorder Controller

Signal Controller

On continuous furnaces separate zones of atmosphere control can be established and automatically maintained.

If manual control is preferred the Autocarb line includes simple recorders or indicators.

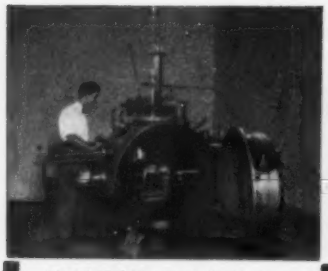
On batch furnaces the Autocarb system will maintain the desired carbon potential for each temperature established in the heating chamber.

On endothermic gas generators Autocarb systems automatically and continuously compensate for fluctuations in the composition of the reaction fuel gas supply and the humidity of the reaction air. This keeps constant the dew point of the product gas.

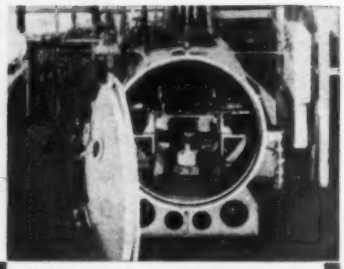
BRITISH FURNACES LIMITED—CHESTERFIELD

ASSOCIATED WITH SURFACE COMBUSTION CORPORATION · TOLEDO—U.S.A.

. . . COULD A VACUUM FURNACE DO THE SAME FOR YOUR PRODUCTS?



Model 2555 Vacuum Induction Furnace with melting capacity of 50 pounds of steel. Other standard furnaces have capacities of 12 to 3,000 pounds.



Model 2705 Non-Consumable Arc Skull Furnace with a capacity of 50 pounds of titanium. Other standard vacuum arc furnaces have capacities of 8 to 10,000 pounds of titanium.

Metals for parts to withstand jet engine temperatures and stresses can be produced in vacuum furnaces. Such metals enable components to be made with fewer rejects. If your products need parts that operate under severe conditions or need high purity metals or alloys—a vacuum furnace will help you to produce them.

Wild-Barfield can supply equipment made to the designs of and tested by the unrivalled experience of the National Research Corporation who have built and operated more high vacuum furnaces than any other company in the world.

Write for details of the Wild-Barfield—NRC range of high vacuum plant.

WILD-BARFIELD—NRC EQUIPMENT INCLUDES:

VACUUM INDUCTION FURNACES
VACUUM ARC FURNACES
VACUUM RESISTANCE FURNACES
VACUUM ANALYSING EQUIPMENT
HIGH VACUUM DIFFUSION PUMPS
LABORATORY VACUUM FURNACES

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ELECTRIC WILD BARFIELD FURNACES

for* all *heat-treatment purposes

WILD-BARFIELD ELECTRIC FURNACES LIMITED

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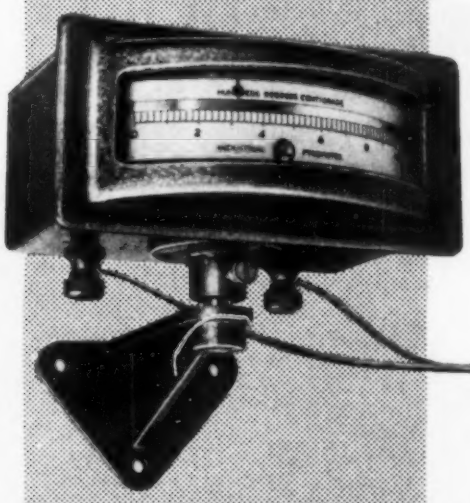
WB 84

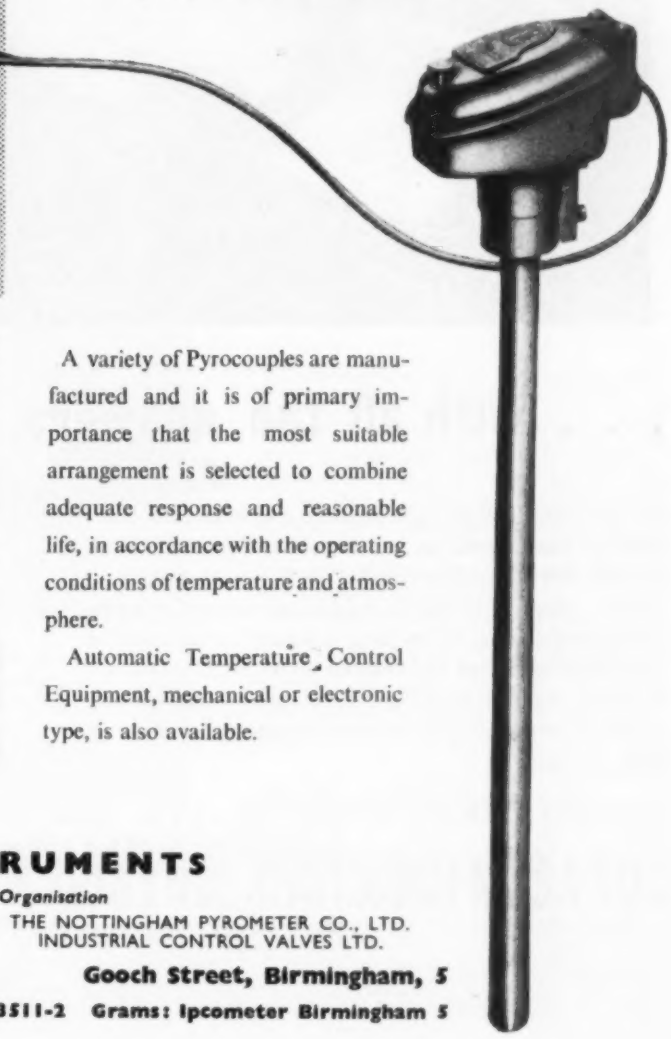
PYROSCALE EDGEWISE INDICATORS

AND PYROCOUPLES



Pyroscale Edgewise Indicators are designed for use on Furnaces, Salt and Metal Baths, Ovens and Infra-red tunnels, Diesel Engines, Boilers and Power Plant, Diecasting Machines, Injection moulding machines and other applications where accurate temperature measurement is vital.

They are available for wall and flush panel mounting in calibrated scale lengths of 4", 6" and 8" and have a knife edge pointer with anti-parallax mirror, which ensures accurate readings. They combine robustness and accuracy to give a high quality instrument at reasonable cost.



- PYROSCALE EDGEWISE INDICATORS
- PYROSCALE PORTABLE INDICATORS
- PYROSWITCH MULTI-POINT PYROMETERS
- PYROCOUPLES
- FOUNDRY PYROMETERS
- INDICATING PYROMETERS CONTROLLERS
- MECHANICAL PYROSTAT CONTROLLERS
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A variety of Pyrocouples are manufactured and it is of primary importance that the most suitable arrangement is selected to combine adequate response and reasonable life, in accordance with the operating conditions of temperature and atmosphere.

Automatic Temperature Control Equipment, mechanical or electronic type, is also available.

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Phone: MIDland 3511-2 Grams: Ipcometer Birmingham 5

Picture of a man . . .

. . . with all the answers on insulating bricks

He is finding that the use of insulating bricks for more effective heat insulation has been a subject well worth looking into. Reading further he'll see that Newalls make a range of insulation bricks under the trade names "Nonpareil" and "Newparex" which are designed to cover heat insulation requirements up to 2012°F (1100°C). But why not read the catalogue yourself? Like the man in the advertisement, you'll find factual answers to all your queries.

Write to us for a copy of our
INSULATING BRICK CATALOGUE
which will be supplied free on request.

Newalls

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A member of the TURNER & NEWALL ORGANISATION
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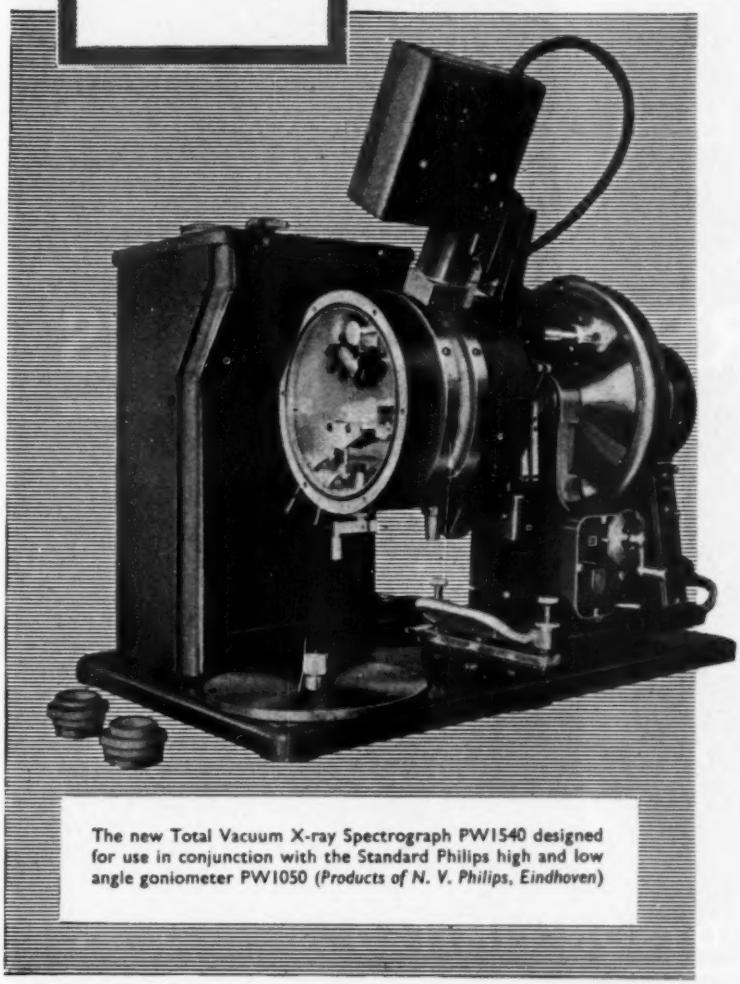
Quality Control

through X-ray spectrography

NOW—DOWN TO MAGNESIUM!



The new Total Vacuum X-ray Spectrograph PW1540 designed for use in conjunction with the Standard Philips high and low angle goniometer PW1050 (*Products of N. V. Philips, Eindhoven*)

PHILIPS new Total Vacuum Spectrographic Attachment PW1540 makes an outstanding scientific advance available to industry. The advantages of X-ray spectrography (non-destructive, rapid, qualitative and quantitative analysis) are now extended to all elements from uranium *down to MAGNESIUM.*

Special features of Philips PW1540 Total Vacuum Spectrographic Attachment:—

1. Total Vacuum allowing detectability down to magnesium.
2. Built-in flow proportional detector.
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This application service for industry has helped many . . . it may help you too!

Your most obstinate problem of quality control may possibly be solved by the unique properties of X-ray spectrography. Arrangements have been made between Research & Control Instruments Limited and N. V. Philips, Eindhoven, whereby the experience and facilities of the world-famous Philips X-ray analysis laboratories can be placed at your service. The problem will be studied by specialists and their conclusions can be discussed in your own works. This service is entirely free. Write to us now.

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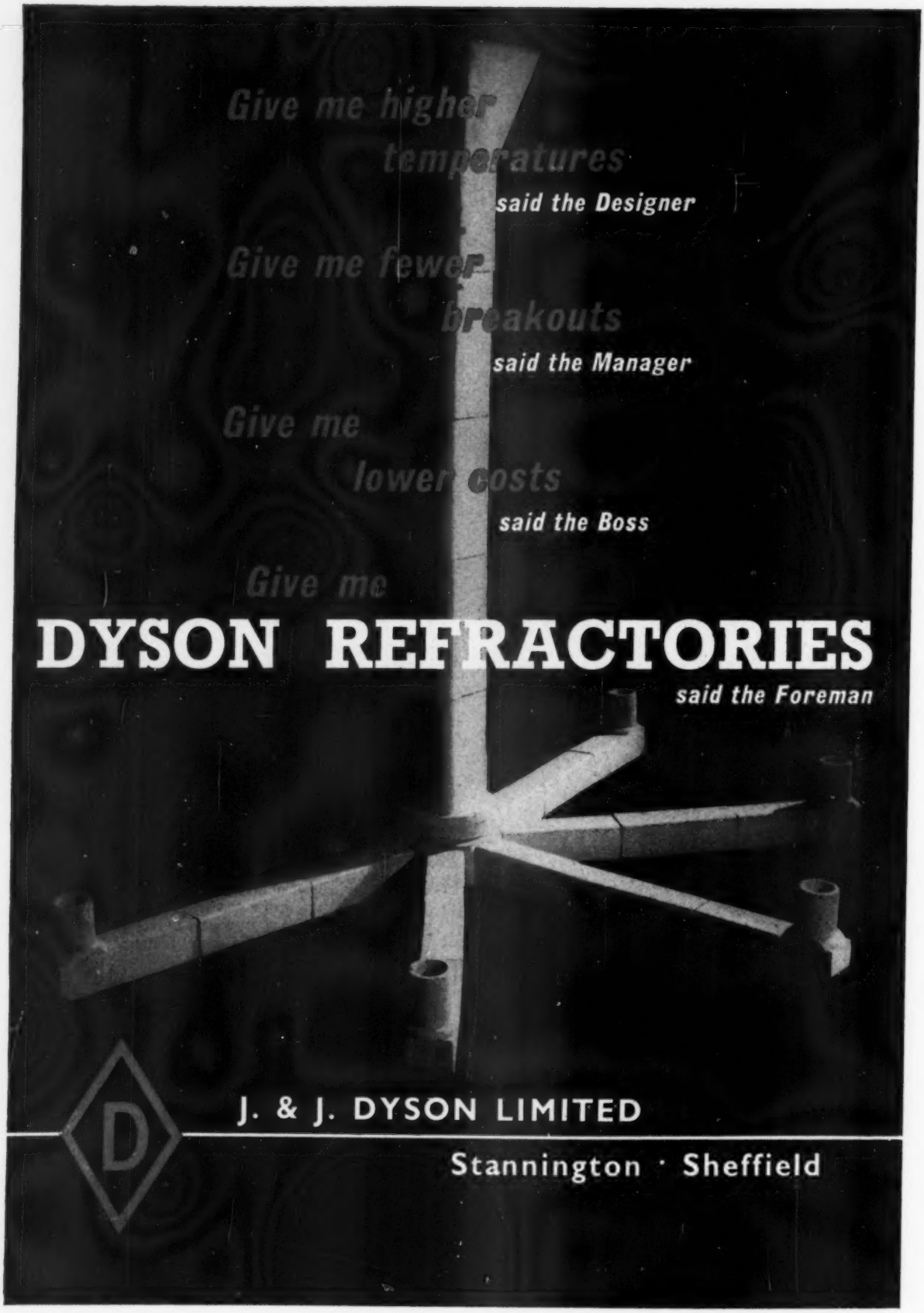
Give me higher temperatures
said the Designer
Give me fewer breakouts
said the Manager
Give me lower costs
said the Boss
Give me
DYSON REFRACTORIES
said the Foreman
J. & J. DYSON LIMITED
Stannington · Sheffield

METALLURGIA

THE BRITISH JOURNAL OF METALS
INCORPORATING THE METALLURGICAL ENGINEER

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For

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METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER"

JULY, 1959 Vol. LX. No. 357

Research Association Finance

"WE are firmly of the view that co-operative research brings important specific benefits to industry. It economises on money and scientific manpower. It offers a scientific service to firms that cannot afford research departments of their own. It helps to guide industry towards an appreciation of the value of research in general. It facilitates the exchange of technical information and other forms of mutual assistance. Finally, it builds a store of knowledge on which the nation, through Government departments, can draw."

So says the Industrial Grants Committee of the Department of Scientific and Industrial Research in its statement of policy on research associations. It is contained in "Research for Industry, 1958," a report* on work done by individual research associations embraced by the Government scheme. The importance of the application of science in industry was strikingly brought home to the Government during World War I, when deficiencies in production had to be made good quickly, and in 1917 the Department of Scientific and Industrial Research was set up and allocated £1 m. with which to encourage industry to set up research associations, and thus to convince it of the value of scientific research. Today the combined annual income of the 49 grant-aided organisations is about £6½ m. and is increasing steadily. The Committee envisages that the total grant to research associations in the Government scheme will be a third higher in the next five years than in the period 1954-59, and that the total grant earning income will go up by nearly half. While this implies a big expansion of existing research associations, the Committee expects one or two new associations to be formed, pointing out that almost a fifth of the net output of British manufacturing industry is not properly covered by existing research facilities, and that some of these trades may, in the future, be appropriately served by grant-aided research bodies.

During the forty-two years which have elapsed since the research association idea was first conceived, there have been changes in the Government's attitude towards its financial responsibilities in connection with the venture. Prior to World War II, it was assumed that the associations would eventually support themselves entirely, but in 1945 Mr. Herbert Morrison, then Lord President of the Council said, "Now it has been decided that, in the national interest, grants to research associations will form a permanent part of the activities of the Department." Nevertheless, it is the aim to make the various associations as self-supporting as possible.

The extent to which the Department aids an association financially is based on a number of factors, and is reviewed by the Committee from time to time. The general procedure involves the award of a basic block grant, supplemented by an incentive payment which varies (up to a maximum) with the amount subscribed to the association concerned by its industrial members. As the object of Government aid is to encourage the formation of research associations where they are needed, and to help them over the difficult early years, when, on the whole the industries concerned are only beginning to appreciate their value, it follows that the help is most generous to a young association struggling to establish itself. As progress is made, and more and more support is received from industry, the incentive payment is gradually reduced, until it ceases altogether when the association reaches an appropriate size. Since this policy of reducing incentive grants was introduced in 1951, the overall ratio of grant to industrial income has fallen from 1 : 1·65 to 1 : 2·5, and the lowest individual ratio is 1 : 4·6. It is important, however, that grants should not be reduced too quickly, thereby discouraging industrial research. That this point is appreciated by the Committee is evident from the statement in the report; "We are determined not to weaken valuable incentives in over-ardent pursuit of economy. But we are equally certain that the autonomy of research associations must be preserved and that we should do all we can to strengthen the financial basis of it."

The term research is often qualified by such adjectives as academic, industrial, basic, pure, applied and sponsored. In the case of the universities, most of the research work undertaken is of the pure or academic type, its object being the advancement of our knowledge and understanding of some particular aspect of science, with little regard for the use to which the results may be put. At the other extreme, research in an industrial laboratory is mainly concerned with the processes and products of a particular firm, with a view to developing one or the other for the exclusive benefit of the firm. Between the two lies the class of work in which research associations can most profitably engage. The Industrial Grants Committee considers it most important that a proper balance should be maintained between basic research, applied research and information, liaison and consultant services. A recent survey of the activities of some thirty-two research associations has shown that, on average, some 28% of the total effort has been devoted to basic research and 63% to applied research.

The Committee takes the view that research associations should be encouraged to do a reasonable amount of sponsored research, so long as co-operative research programmes do not suffer, since it gives research workers useful experience, strengthens the contacts with industry, adds to the total income, and helps to spread the cost of research equipment. In future, grant-aided associations need not consult the Committee before undertaking sponsored projects, unless the income is likely to exceed 15% of the total income in any year, or unless the estimated cost of any one project is over £5,000.

* Published by H.M. Stationery Office, price 7s. 6d (8s. by post), $1.35 in the U.S.A.

DELAY IN PUBLICATION

The publishers regret that as a result of the dispute in the printing industry the publication of this issue has been delayed. It is hoped to complete publication of the six issues making up Vol. LX before the end of the year.

Personal News

Sir Alexander Fleck, Chairman of Imperial Chemical Industries, Ltd., who has been with the Company and its predecessors for over 44 years, is to retire at the end of February, 1960. Sir Alexander was appointed a Director of Imperial Chemical Industries, Ltd., in 1944, a Deputy Chairman in 1950 and Chairman, in succession to Mr. John Rogers, in 1953. Mr. S. P. Chambers, who joined the Board in 1947 and was elected a Deputy Chairman in 1952, is to succeed Sir Alexander.

Dr. K. J. Irvine has relinquished his duties as Head of the Metallurgy Section of the Research and Development Department of The United Steel Cos., Ltd., to become Deputy Research Manager. The Metallurgy Section has been reconstituted, and Mr. J. D. Murray has been appointed Head of the Applied Metallurgy Section, embracing high temperature metals, alloy development and welding; and Mr. F. B. Pickering is Head of the Physical Metallurgy Section dealing with the more fundamental aspects of the subject.

Mr. L. H. Cooper has relinquished his position as Chairman and Director of The Mond Nickel Co., Ltd., and Henry Wiggin and Co., Ltd., and is succeeded in these capacities by Mr. G. Archer. Three Managing Directors of Mond have been appointed, namely, Mr. I. A. Bailey (Operations), who continues as Managing Director of Wiggin, and Dr. L. B. Pfeil (Research and Technical) and Mr. J. O. Hitchcock (Commercial), both of whom continue as Directors of Wiggin. Dr. A. G. Ramsey, the Director of Mond resident at Clydach, has also been appointed a Director of Wiggin, and Mr. F. Dickenson, Manager of the Mond Development and Research Department is now a Director of Mond. Mr. F. B. H. Howard-White and Mr. R. A. R. Hill, while continuing as Directors of the two Companies, have relinquished their respective positions as Secretary and Comptroller of both Mond and Wiggin, their successors in these offices being Mr. E. Vaughan and Mr. D. Parry Davies. Mr. C. W. R. Edwards has been appointed Chief Legal Officer of Mond and Wiggin and continues as Assistant Secretary of both Companies.

Following the retirement of Mr. A. G. Snape, Dr. B. B. Hundy has been appointed Chief Research Metallurgist to the Steel, Peech and Tozer Branch of The United Steel Cos., Ltd. Mr. P. B. Dunnill has been appointed to succeed as Chief Chemist Mr. D. Manterfield, who has also retired. Both Mr. Snape and Mr. Manterfield will be available in an advisory capacity until the end of June, 1960.

In an announcement on p. 264 of the June issue, concerning Atomic Power Constructions, Ltd., it was stated that Mr. D. C. F. Lum had been appointed Chief Metallurgist. The name should have read Mr. D. C. F. Lunn: we regret any inconvenience caused to Mr. Lunn as a result of this error.

British Driver-Harris Co., Ltd., announce the appointment of two new Directors: Mr. H. E. R. Thomas—for several years Sales Manager under the direction of Mr. W. Eyers, Sales Director—has been made Commercial Director; and Mr. E. Shuttleworth, Technical Adviser to the President of Driver-Harris, Harrison, N.J., U.S.A., has also been appointed a Director of the British Company.

Appleby-Frodingham Steel Co., a Branch of The United Steel Cos., Ltd., announce that Mr. A. Howard has been appointed Assistant to Dr. L. Reeve, Chief Metallurgist, with the title of Research Manager. Mr. E. E. Clark has been appointed Works Metallurgist and will be responsible directly to Dr. Reeve for all metallurgical services at the Appleby-Frodingham works.

Mr. I. H. Gordon has been appointed Assistant Sales Manager of Cambridge Instrument Co., Ltd. Previously, he was Southern Area Manager of Land Pyrometers, Ltd., and, prior to that, was with Evershed and Vignoles, Ltd.

Mr. J. S. Anderson, who recently resigned as Deputy Provincial Treasurer of the Province of Manitoba, has been elected Assistant to the Vice President and also Assistant Treasurer of The International Nickel Co. of Canada, Ltd.

Mr. J. F. Robertson, a Director and Group Treasurer of the Hawker Siddeley Group, has been appointed to the Board of High Duty Alloys, Ltd., a member of Hawker Siddeley Industries, Ltd. Another new appointment to the Board of High Duty Alloys is that of Mr. I. C. Dick, the Company Secretary.

Sir James Young has vacated his seat on the Board of Vickers, Ltd., on reaching retirement age. Mr. W. D. Opher, a Director of Vickers-Armstrongs, Ltd., and of certain other Group Companies, and Managing Director of Vickers-Armstrongs (Engineers), Ltd., has been appointed a Director of Vickers, Ltd.

British Insulated Callender's Construction Co., Ltd., announce the appointments of Mr. J. N. Gibson, Mr. J. R. McDonald and Mr. D. M. H. Rooney as Executive Directors.

Obituary

We regret to record the death of the following:

Dr. J. E. Hurst, C.B.E., who died on Sunday, June 20th, 1959. Following service with a number of companies as a metallurgist, Dr. Hurst became Technical Adviser to Bradley and Foster, Ltd., in 1926, Technical Director in 1934, Managing Director in 1949, and Deputy Chairman in 1952, from which position he retired at the end of last year on the grounds of ill-health. During a long working life associated with the metallurgy of cast iron, his special interests included the development of the centrifugal casting process, the heat treatment and nitriding of cast iron, and the production of alloy cast irons. In 1939 he was awarded an honorary Doctorate of Metallurgy of the University of Sheffield and an honorary Doctorate of Engineering of Karlsruhe in 1956.

The technical bodies which elected Dr. Hurst as President included The Institute of British Foundrymen, The British Cast Iron Research Association, The Institute of Vitreous Enamellers, the National Trades Technical Societies and The Staffordshire Iron and Steel Institute. Further recognition of his services to industry was made in 1953, when he became a C.B.E. in the Coronation Honours List. Dr. Hurst was prominent in the life of the city of Lichfield: he was made a J.P. in 1942 and Sheriff in 1946.

Sir Frederick Pickworth, Chairman of English Steel Corporation, Ltd., who died suddenly on Tuesday, July 14th, 1959. Knighted in 1957, Sir Frederick was also a Director of Vickers, Ltd., English Drilling Equipment Co., Ltd., (Chairman), High Speed Steel Alloys, Ltd., The Steetley Co., Ltd., and the American controlled Security Rock Bits, Ltd. (Chairman).

After some years on the works staff, Sir Frederick joined the accountancy staff of Cammell Laird and Co., Ltd., Sheffield, in 1911 and was appointed Chief Accountant in 1917, having previously been Chief Accountant of Nottingham Shell Factory. In 1929, shortly after the formation of English Steel Corporation, Ltd., he was appointed Secretary of that Company, being elected to the Board in 1936 and becoming Managing Director in 1944 and Chairman in 1955.

Sir Frederick was a member of the Council, Executive Committee and a number of other Committees of the British Iron and Steel Federation. He was also Chairman of the National Forgemasters' Association and the Federated Forgemasters, and a member of the Management Board and various Committees of the Engineering and Allied Employers' National Federation. A member of the Company of Cutlers in Hallamshire, Sir Frederick held the office of Master Cutler for 1957–58. He was also a member of the Council and Finance Committee of Sheffield University, and of its Court of Governors.

Mr. L. K. Everitt, a Director of Edgar Allen and Co., Ltd., and General Manager of the Steel Department, who died suddenly in Paris while on a visit to their subsidiary company, Acieries d'Hirson. Mr. Everitt, son of the late Mr. C. K. Everitt, former Chairman of the Company, was born in Sheffield in 1902, and educated at King Edward VII School and Sheffield University. He joined the Company in 1924, and spent twelve months in South Africa, Rhodesia and the Belgian Congo in 1926. Under Mr. Everitt's guidance, the first high-frequency melting furnace in the world for the manufacture of high grade tool steel was installed in 1927, and he became Manager of the Steel Department in 1928: he was elected a Director of the Company in 1937.

Mr. H. S. Carpenter, former Chairman and Managing Director of Kodak, Ltd., who died on Saturday, June 27th, 1959. Mr Carpenter joined the Company in 1913 and was appointed Manager of the Bombay Branch in 1920. He returned to Head Office in 1925 and was appointed General Sales Manager in 1932, becoming Deputy Managing Director in 1935. Mr. Carpenter was Managing Director from 1945 to 1957 and Chairman from October 1954 to January 1958. He was taken seriously ill during a visit to America in 1957, and the Board regretfully accepted his resignation as a Director of Kodak, Ltd., from September 1st, 1958.

Mr. W. A. Moody, Vice-Chairman of The Lancashire Wire Co., Ltd., who died on Sunday, June 7th, 1959. Mr. Moody was educated at Huddersfield Technical College and was engaged in hydraulic and general engineering for some years, entering the wire industry as Technical Supervisor in 1906. He was appointed a Director of the Lancashire Wire Company in 1914 and was Managing Director from 1923 to 1955.

New Electric Steelmaking Plant

Interesting Extension at Brymbo Steel Works

View of the new melting shop from the south-east. The tunnel giving access to the works can be seen on the left, with new buildings above it.

In the June issue of METALLURGIA *an account was given of a pre-refining technique developed by Brymbo Steel Works, Ltd., which makes possible the use of a hot metal process in an electric arc steel melting plant. The official inauguration of the plant erected at Brymbo to exploit this development took place on May 26th, in the presence of some 150 guests, when Lord Brecon made the official opening speech. A brief description of the plant, whose construction presented a number of unusual problems, is presented here.*

IN 1955 there began at Brymbo Steel Works a major operation in civil engineering. The only site available for the new oxygen-electric melting shop was the open hearth slag tip, which took the form of a long narrow shoulder, some 80 ft. high and 60 ft. wide, stretching out into the valley below. This "bank," as it was commonly known, looked very inert until soundings were taken which indicated that well below the surface it was, in fact, on fire. Producer ash, which had for many years been tipped alongside the open hearth slag, was obviously well alight, and following discussions with consultants (International Construction Co. Ltd.), a decision was taken to remove it. Sir Alfred McAlpine and Son, Ltd., the well-known contractors, were chosen to undertake this very difficult task. Underneath the "shell" of the bank surface was a blazing inferno of semi-fused ash and slag which strongly resisted all attempts to remove it. Thousands of gallons of water were poured into the fissures and behind the large boulders of fused clinker, some of which had the elasticity of semi-molten silica, and the process of disintegration and removal was extremely difficult.

Re-filling the Site

Some 80,000 cu. yd. of this red-hot material had to be removed before the process of re-filling with blast furnace slag commenced. The amount of fill required in order to make sufficient area for the new plant exceeded 180,000 cu. yd., most of which was taken from the opposite side of the bank and mixed with arising blast furnace slag. This was laid down in 2 ft. thick layers and firmly consolidated with bulldozers before work on the foundations commenced. The total time taken for this operation was in the region of nine months, and work commenced on the foundations for the new shop in June 1957.

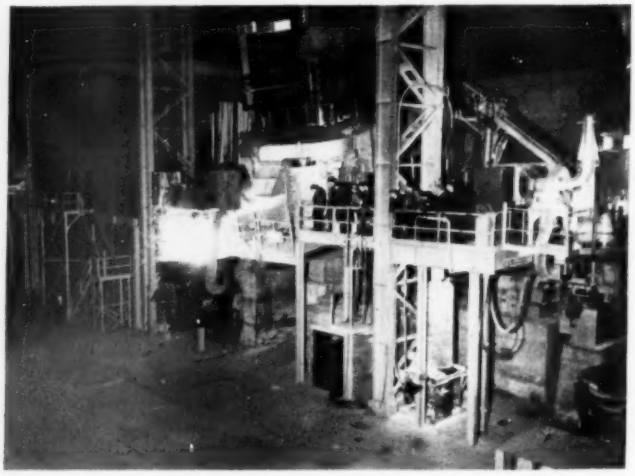
The next operation was to construct a tunnel over the narrow road which separated the scrap stock yards from the melting shop, and had virtually split the works in two since the early years. Designed and constructed by Sir Alfred McAlpine and Son, Ltd., the tunnel is in the form of a parabolic arch and extends for approximately 400 ft. It has greatly enhanced the site and recovered 73,000 sq. ft. of useful ground, making it possible to bring the scrap direct to the melting shop, instead of taking it across a narrow bridge some distance away. New offices, maintenance department, workshops and an amenities block have been built on the site above the tunnel.

Once the tunnel had been erected and the adjacent valley filled in, care being taken to see that the fill had been consolidated around the tunnel, work on the foundations of the outside columns was completed. The foundations were designed by G.K.N. Reinforcements, Ltd., to take a load of 1½ tons/sq. ft. This was sufficient to take the load of two 65 ton cranes running alongside each other.

Features of the New Melting Shop

The new oxygen-electric melting shop consists of two parallel bays, 432 ft. long by 50 ft. wide; it is a steel framed building with a tubular monitor roof. The main gantry girders are of all-welded construction, and the rail joints on the gantry are also welded to give smooth running conditions for the overhead cranes. Both sides of the building have extensive glazing to give overall natural lighting to the building. In the scrap yard, two 60 ton rail weighing machines are installed, and three

Charging pre-refined hot metal to one of the 40 ton electric arc furnaces.



Tapping one of the 40 ton electric arc furnaces. The water cooled lance of the pre-refining furnace is seen on the right with the lime powder dispenser below.

scrap transfer cars are used to move the scrap baskets (after they have been filled and weighed in the scrap yard) to the melting shop, where they are placed on stands ready for charging into the electric arc furnaces.

In the charging bay itself, there are three 40 ton Birlec arc furnaces, one 150 ton mixer and one 20 ton oxygen pre-refining vessel, which was described in the June issue of METALLURGIA. Immediately behind the furnaces are the storage bunkers holding the flux materials, which are fed into the furnaces by a mobile charger. The working platform for the furnaces is 18 ft. high, and is so designed that valuable floor space is available under it for the storage of raw materials associated with steelmaking. Railway lines are laid under the platform to enable the slag cars to be changed without interfering with the operations on the working platform.

The charging and tapping bays each have three overhead electric travelling cranes, two 60 ton and one 25 ton crane in each bay. The cranes have been made by Sir William Arrol and Co., Ltd., and are all powered by 400 V, 3 phase, 50 cycle A.C. motors, supplied by Metropolitan Vickers Electrical Co., Ltd. The motors are controlled by master controllers and accelerating contactor panels. These master controllers are carefully located in the crane cab so that the driver will have maximum visibility with all controllers easily to hand.

The New Arc Furnaces

The three 40 ton melting furnace units, supplied by Birlec, Ltd., are top-charged, direct-arc tilting furnaces, and have a shell diameter of 16 ft. For charging the furnace, the roof is lifted and swung clear by the use of a hydraulic ram: separate hydraulic rams are used for tilting the furnace. Each furnace has three vertical graphite electrodes, each 16 in. diameter and clamped by high conductivity copper castings which are water cooled. The pressure on the clamp is provided by a heavy spring, which is released for electrode adjustment by an air cylinder: the slagging door and side door are also operated by air. The arches and jambs of the doors, the furnace shell, and the roof rings are water cooled, and each furnace is extensively hooded for fume removal.

Electrode Control

Each electrode is controlled by a motor and winch, a wire rope being taken from the electrode via pulleys to the winch drum and on to counter weights. A special type of D.C. generator is provided for each electrode winch motor. The field excitation of the generator is controlled from opposed voltage and current components of the furnace power circuit, and produces instantly a corresponding but greatly magnified variation in the generator voltage applied to the winch motors. Thus the winch motors are energised in proportion to the degree of out-of-balance in the furnace power circuit, and the electrodes move rapidly to compensate for large changes, and proportionately more slowly for small variations. The electrode motor winches can also be controlled by hand when necessary. This control enables the furnace operator to have complete control over the heat input to the furnace: by merely pressing a button he is able to increase or decrease the heat input to the furnace, which will then remain constant until it is necessary to make a further adjustment.

Furnace Transformers

The transformer on each furnace has been supplied by The English Electric Co., Ltd., and is designed to give maximum output of 12,500 kVA from a 33 kV., three phase, 50 cycle supply. The secondary voltage can be varied in twenty steps from 325 V. to 120 V. The transformer consists of two units in one tank, the first unit acting as regulating transformer and feeding directly into the primary windings of the second unit, which has a fixed voltage ratio. The regulating transformer is auto-wound and star connected. The second unit is double wound, the primary windings being connected in delta, and all ends of the secondary winding brought out for external connection in delta.

It is a feature of the transformer that the tapping variations are made "on load," the tap change control being on the furnaceman's control panel. The tap change unit is by Metropolitan Vickers, and is of the resistor transition type, which gives minimum arcing at the diverter contacts, thus reducing maintenance. The transformer is water cooled, the oil being circulated through duplicate Holden and Brooks oil/water coolers, each of which is capable of dissipating the full load losses of the transformer, under which conditions water consumption is 100 gal./min.

The circuit breaker controlling each furnace transformer is an English Electric 750 MVA. air blast unit, working at 33 kV. and having its own air compressor. Electrically operated closing and tripping valves deliver air to operating cylinders which open and close the circuit breaker. When the breaker is tripped, the air circuit is so arranged that the arcing contacts are opened and the arc is blown out before a port is uncovered for the air to operate the cylinders which open the main contacts. These circuit breakers are specially designed for breaking heavy loads constantly with a minimum amount of maintenance.

Electrical Supplies

Electrical power for the new plant is supplied by the C.E.A., and it was found necessary to bring into the works a new 33 kV. feeder. This is tapped from a new 132 kV. line running from Connahs Quay to Legacy substation. Two 132/33 kV., 20 MVA. transformers feed the works from this supply through a twelve-panel metal-clad switchboard made by Ferguson Pailin, Ltd.

The switchboard is of the single busbar type, and is split by a bus section switch. On the right hand side of the bus section switch are five switches: the incoming oil circuit breaker (O.C.B.); two O.C.B.s feeding the existing electric furnace load; one O.C.B. feeding a 5,000 kVA. transformer (33 kV./3·3 kV.); and one O.C.B. feeding a 4,000 kVAR. synchronous condenser. On the left of the bus section switch are six O.C.B.s: one incoming; one feeding a 5,000 kVA. transformer (33 kV./3·3 kV.); three feeding 12·5 MVA. furnace transformers; and one feeding a 7,000 kVAR. synchronous condenser. All switches are fitted with solenoids for local or remote control. The control room is built above the switch room and houses all control panels, overload protection relays and metering equipment, including maximum demand control.

The Tonnage Oxygen Plant

Owing to the large amount of oxygen used in this process, it was found necessary to build an oxygen plant at Brymbo, and it was decided to instal a 24,000 cu.ft./hr. plant made by Air Products (Great Britain), Ltd. Air Products low-temperature equipment is based on the general design of Air Products Incorporated, U.S.A., who are the major suppliers of oxygen plants to the American steel industry.

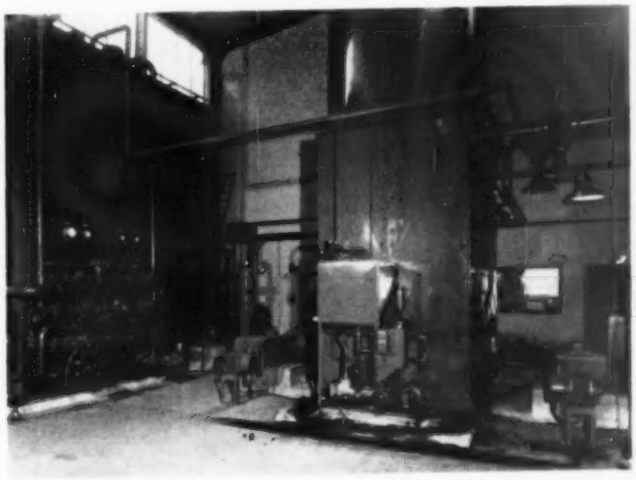
To produce tonnage quantities of oxygen economically, a process whereby refrigerated air is fractionated or distilled into its component parts—oxygen, nitrogen and argon—is employed. The fractionation method is a four stage process: compressed air is water cooled, refrigerated in a heat exchange system, liquefied, and finally distilled. The equipment to produce these effects includes air compressors, heat exchangers, refrigeration systems, expanders and distillation apparatus. The oxygen generator installed at Brymbo Steel Works is of the medium pressure cycle type and the process is outlined below.

A four stage vertical reciprocating compressor delivers air to the plant at a pressure of 750 lb./sq. in. normally, with a maximum of 1,000 lb./sq. in. during the start-up period. Air is taken from the second stage of the compressor at a low pressure and passed through towers where carbon dioxide is removed by scrubbing with a circulating solution of caustic soda. The air then re-enters the final stages of the compressor.

The compressed air leaving the compressor is water cooled in an after-cooler to reduce the heat of compression. It is then fed into one of two desiccant-type air drying towers. These towers are filled with a solid absorbent and are arranged for alternate service on a 12-hour reactivation cycle. The reactivation is effected by part of the dry waste nitrogen product from the plant.

The air is then fed through a tube-in-shell type unit where heat exchange takes place against the cold products from the plant, i.e. oxygen and nitrogen. A part of the air is withdrawn from the exchanger as a side stream at an intermediate temperature point. This side stream is expanded in a turbo-expander to provide additional refrigeration. The two air streams are then reunited and partially liquefied by a final reduction in temperature to −160° C. across an expansion valve.

This partially liquid stream then enters the high pressure distillation column, where it is distilled into two streams, an overhead stream of essentially pure nitrogen and a bottom stream of oxygen rich liquid. The liquid oxygen is then passed through hydrocarbon absorbers consisting of two towers arranged for alternate service. The absorbers operate on a cyclic basis and are reactivated by the heated pure nitrogen product from the plant. The liquid oxygen stream is sub-cooled in an extended surface type exchanger against the cold pure oxygen product stream. It is then expanded to the pressure of the low pressure distillation column, where it is further fractionated and delivered as 99·5% purity liquid oxygen.



Interior of the oxygen plant, showing the fractionating column and instrument panel in the centre, and control valves on the left.

The liquid oxygen product is then pumped by means of two unique self-lubricated reciprocating pumps to pressures up to 2,000 lb./sq. in. After heat exchange against warm incoming air, the liquid oxygen is converted to a dry uncontaminated gas at high pressure for delivery to storage bank or distribution pipe line.

Use of the liquid oxygen pumping cycle pioneered by Air Products dispenses with gaseous oxygen compressors, oxygen driers and gas holders. Another feature of this oxygen generator is the turbo-expander which is used to cool the compressed air feed. This has a considerable effect in reducing the cost of production, and also enables quick restarting of the plant after shut-down. Reduction of moving parts to an absolute minimum and the duplication of equipment ensure optimum reliability and continuity of supply.

New and Revised British Standards

NICKEL COPPER ALLOY CASTINGS (B.S. 3071 : 1959) PRICE 4s.

NICKEL AND NICKEL ALLOYS—SHEET (B.S. 3072 : 1959) PRICE 5s.

NICKEL AND NICKEL ALLOYS—STRIP (B.S. 3073 : 1059) PRICE 5s.

NICKEL AND NICKEL ALLOYS—TUBE (B.S. 3074 : 1959) PRICE 5s.

NICKEL AND NICKEL ALLOYS—WIRE (B.S. 3075 : 1959) PRICE 4s.

NICKEL AND NICKEL ALLOYS—RODS AND SECTIONS (B.S. 3076 : 1959) PRICE 5s.

This series of six British Standards for nickel and nickel alloys supersedes the earlier series, B.S. 1525–1537, issued in 1949. B.S. 1537 referred to one nickel-copper alloy, but its successor, B.S. 3071, includes requirements for two further alloys with higher silicon contents; they have been added to meet Service requirements. The standards for wrought materials have been re-grouped so that one document applies to each wrought form, as in the B.S. 1470–1477 series for aluminium, and in the schedules of wrought copper and copper alloys which are in course of preparation. The requirements for the three materials included in the earlier series of standards have been amended, and a fourth material—low carbon nickel—has been included for some forms. Code numbers have been allocated to them and are used throughout the series, but associated with the British Standard number for each wrought form. Sheet and strip material, previously dealt with under one cover, are now the subject of separate standards, as different tolerances apply and low carbon nickel is not normally supplied in strip form.

MAGNESIUM AND MAGNESIUM ALLOY INGOTS AND CASTINGS FOR GENERAL ENGINEERING PURPOSES (B.S. 2970 : 1959). PRICE 8s. 6d. (POSTAGE EXTRA TO NON-SUBSCRIBERS).

THIS new publication (42pp., illustrated) supersedes the earlier series of standards for magnesium alloy ingots and castings—B.S. 1272–1280. The requirements of the earlier standards have been amended in the light of more recent experience in magnesium alloys. Specifications for pure magnesium ingots, and for five new alloys in various conditions, have been added. The new specification has been modelled on B.S. 1490 (aluminium alloy ingots and castings) in that general requirements are grouped in Sections I and II for ingots and castings, respectively, and specific requirements for each material are included in separate sections. Alloy numbers have been allocated to each material prefixed by the letters "MAG" and symbols are used to indicate form and condition, as in B.S. 1490.

COPPER SULPHATE TEST AND VISUAL EXAMINATION OF HOT DIP GALVANISED AND SHERARDISED COATINGS (B.S. 729 : 1959) PRICE 3s. (POSTAGE EXTRA TO NON-SUBSCRIBERS).

B.S. 729 was first published in 1937, to provide a standard method of test for hot dip galvanised and sherardised coatings on articles other than wire. In this revision, the range of articles has been specified with size limitations. It includes bolt, nuts and other threaded articles of similar size; articles fabricated from strips, bars or tubes; and castings, angle brackets and structural shapes. For larger fabricated articles, and for grey and malleable iron castings, a further standard is in preparation. The copper sulphate test has not been supplanted; it is now presented in a simplified form. Mention is made in an appendix of electronic thickness gauges, which, whilst potentially valuable, are not yet felt to have attained a degree of development comparable with the copper sulphate test.

METHODS FOR THE ANALYSIS OF IRON AND STEEL (B.S. 1121) PART 39 : 1959 NITROGEN IN STEEL. PRICE 4s. (POSTAGE EXTRA TO NON-SUBSCRIBERS).

THIS new publication (11pp., 2 full page illustrations) specifies a method for the determination of nitrogen in all types of steel containing up to 0·25% nitrogen. Complete nitrogen recovery, the standard points out, cannot be obtained from steels containing silicon and nitride. B.S. 1121 : Part 39—which forms part of a programme of standardising methods for the determination of elements in iron and steel—will be of particular value as a referee method.

Copies of these standards may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

THE GENERAL ELECTRIC CO., LTD., and Wild-Barfield Electric Furnaces, Ltd., jointly announce that with effect from July 1st, 1959, the repair and maintenance service for all G.E.C. valve-operated high frequency generators will be carried out by Wild-Barfield Electric Furnaces, Ltd., from their works at Otterspool Way, Watford By-Pass, Watford, Herts. Tel.: Watford 26091.

A NEW Canadian Company, Chryslum, Ltd., is being formed by Aluminium Company of Canada, Ltd., in a joint venture with Chrysler Corporation of Canada to produce and supply aluminium alloys for Chrysler automobile plants in Canada and the United States.

Tungsten for Electric Lamp Filaments

By D. J. Jones, B.Sc., F.I.M. and A. Leach, B.Sc., A.R.I.C.

(Research Laboratories of The General Electric Company Limited, Wembley, England).

Powder metallurgy owes much to the electric lamp industry, which developed its basic methods for the production of tungsten lamp filaments. The extraction of the metal from its ores and its manufacture into filaments by compacting, sintering, swaging and wire-drawing are described briefly, and factors influencing the stability of the metallographic structures are discussed in relation to the service behaviour of the lamp.

THE first practical electric lamps were produced independently about 1880 by J. W. Swan in England and T. A. Edison in America, both of whom used carbon filaments. Apart from osmium and tantalum, carbon had no rival as a filament material until 1904, by which time tungsten had established itself in this field. Because of its high melting point, low vapour pressure, and good strength at elevated temperatures, tungsten is ideally suited as a filament for incandescent lamps.

The commercial development of tungsten has, from the beginning, been closely associated with the incandescent lamp industry, although even at the present time only a relatively small percentage of the ore which comes on the market is used in this industry. The importance of tungsten, however, is the direct result of work carried out in the lamp field, and, in fact, the powder metallurgy technique owes its inception to the lamp industry, which developed and employed its basic methods.

Tungsten remained one of the rare elements for many years, and though Oxland took out a patent in 1847[1] for the manufacture of sodium tungstate, tungstic acid and tungsten from cassiterite, it was not until almost fifty years later that the metal itself was employed in the manufacture of electric lamp filaments. Developments in the use of tungsten for lamp filaments commenced about 1904, and it has been used exclusively ever since. Present day manufacture of tungsten wire, by pressing the metal powder in a mould, sintering the pressed compacts at a high temperature, swaging and drawing into wire, is based on developments originated by Coolidge[2, 3] in 1909.

In the manufacture of tungsten powder, only two ores, Wolframite—(FeMn) WO_4—and Scheelite—$CaWO_4$—are of commercial importance, and they are supplied as concentrates in form ranging from coarse particles to large lumps. Apart from the presence of iron, manganese and calcium, tungsten concentrates contain only a small percentage of other elements, and representative analyses of some typical concentrates from different parts of the world are given in Table I.[4]

Initial treatment of the concentrates comprises grinding by ball-milling, and, in general, it is common practice to mill until 95% of the product passes a 200 mesh sieve. In this physical condition the ore concentrates are ready for chemical treatment. The initial stage in the preparation of metallic tungsten is the separation of tungstic acid from the other constituents in the ore, the method used depending on the type of ore.

Tungstic Acid from Wolframite

In general, the method consists of treating Wolframite with strong caustic soda solution. The ore, in quantities of 2,000–4,000 kg., is charged into a steel tank, the requisite quantity of caustic soda is added, and the charge is heated to boiling point by either internal or external means. Ores of high purity decompose readily, but an excess of 50% of the caustic soda solution is required to bring about rapid decomposition with low grade ores. The mixture is boiled and stirred constantly for 4–8 hours, then diluted to twice its volume to cause further precipitation of the iron and manganese hydroxides and to prevent separation of sodium tungstate crystals.

The sodium tungstate resulting from the decomposition of Wolframite is then converted to calcium tungstate by the addition of calcium chloride to the solution :

$$Na_2WO_4 + CaCl_2 = 2\ NaCl + CaWO_4$$

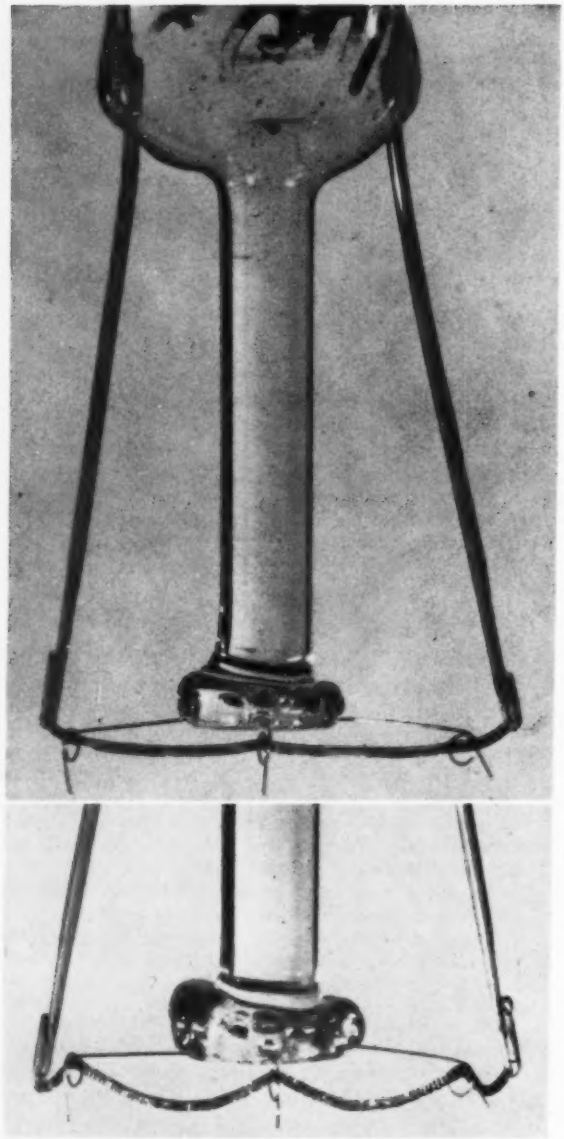
After thoroughly washing the white precipitate by decantation, the calcium tungstate is then treated in a similar manner to Scheelite.

Tungstic Acid from Scheelite

It is common practice[5] to decompose the Scheelite directly with hydrochloric acid in rubber-lined steel tanks. The vessel is fitted with a rubber-coated mechanical stirrer and a rubber-lined discharge valve at the base of

TABLE I.—ANALYSIS OF TYPICAL CONCENTRATES

Type of Ore	Source	Composition (%)														
		WO_3	FeO	MnO	CaO	MgO	SiO_2	Al_2O_3	SnO_2	CuO	MoO_3	TiO_2	Ta_2O_5 Nb_2O_5	Sb_2O_3 Bi_2O_3	As, S,P.	Other Elements
Wolframite	Spain	66·34	12·83	9·89	0·14	0·05	3·91	3·69	1·17	0·05	Trace	0·03	0·17	0·23	0·52	—
	China	68·30	10·29	10·70	0·20	0·09	1·95	0·41	1·64	0·03	0·03	0·05	1·06	0·14	0·34	0·24
	Australia	72·50	16·80	7·70	—	—	—	—	0·63	0·21	—	—	—	—	0·70	—
Scheelite	Australia	78·15	—	—	19·40	0·11	1·39	0·21	—	Nil	Nil	Trace	—	Trace	0·10	—
	South Africa	72·53	0·80	0·39	18·49	0·11	3·56	0·35	Trace	—	2·76	—	—	—	0·03	—
	Canada	74·85	1·90	0·39	18·73	0·20	1·19	0·66	Trace	—	0·39	—	0·09	Trace	0·45	—



(a)

(b)

Fig. 1[8].—Tungsten filaments after 1,000 hours burning at c. 2,400° C.—(a) stable filament ; (b) unstable filament.

the dome-shaped bottom of the vessel. Each kilogramme of ore requires 1–1·5 litres of concentrated hydrochloric acid. This is run into the vessel, the stirrer started, and the charge slowly introduced. The solution is boiled for about 3 hours by injecting dry steam into the liquid The steam is then shut off and nitric acid is added to ensure the highest efficiency in recovery of tungstic acid. As the reaction may be violent, the addition is made slowly and continued until the reaction ceases. The charge is boiled for a further 30 minutes to drive off all gaseous products of the oxidising process. The vessel is then filled with water, stirred for a further 5 minutes, and the sludge allowed to settle, after which the liquor is siphoned off.

The sludge residue consists of tungstic acid (H_2WO_4) and insoluble materials, such as silica : it is then washed free of soluble impurities such as calcium chloride by boiling water. The solid remaining may contain as much as 98–99% of WO_3, or as little as 80%, depending on the type and grade of ore used. The chief impurities are undecomposed ore, silica and silicates, cassiterite, iron, molybdenum and calcium.

The sludge undergoes further purification by extracting the tungstic acid with ammonia, forming ammonium tungstate. At this stage, magnesium chloride and ammonium sulphide may be added to remove traces of arsenic and to precipitate other metals such as molybdenum and iron. The ammonium paratungstate crystals may be obtained from the tungstate solution, either by evaporation or precipation with hydrochloric acid. The resulting crystals, if sufficiently pure, may be decomposed by heat to tungstic oxide or, if further purification is required, dissolved in a potash solution from which tungstic acid is precipitated by the addition of hydrochloric acid.

Oxide Reduction

At the oxide stage it is convenient to introduce "additives," such as thoria, alkali, silica and alumina, that are required in the tungsten metal for certain lamp and valve applications. Before this, however, it is extremely important to control, within close limits, the chemical and physical characteristics of the oxide, to ensure that a constant product is available for the subsequent reduction process.

In order to have accurate control over the physical characteristics of the metal powder, reduction of the oxide is carried out in two stages. For this, gas or electrically heated furnaces with at least three separately controlled heating zones, are required. The first reduction to blue or brown oxide is carried out at temperatures of 450°–700° C., and the final reduction to metal powder at temperatures of 650°–850° C. The atmosphere for reduction is oxygen-free dry hydrogen and, as it is essential to control the state of aggregation and particle size of the tungsten powder produced, such variables as temperature, time and hydrogen flow are kept constant. The conditions of reduction are determined by the type of powder required. For lamp purposes, this ranges from 0·1–5 microns, with the majority of the particles lying between 1 and 2 microns. Before pressing, the powder is sieved and, if necessary, rolled or tumbled.

Production of Wire

For subsequent working to wire, the powder is pressed into square or rectangular bars in low alloy steel moulds which may be up to 24 in. long by 1 in. by 1 in. square. With this shape, die construction is simplified by using double action presses with horizontal as well as vertical motion. Pressures range from 15–25 tons/sq. in. As the pressed bars are fragile, they are heated to 1,100–1,300° C. in a hydrogen atmosphere before sintering.

Sintering is carried out in vertical water-cooled copper bell jars. The bar is held at the top between a pair of heavy copper blocks faced with tungsten strips, with a tungsten or molybdenum clip attached to its lower end, which is immersed in mercury. The sintering temperature of *c.* 3,000° C. is obtained by passing through the bar at low voltage, electric current, which for the larger bars

is over 5,000A. During sintering, the bars contract about 16–18%, with a corresponding increase in density from about 11 to 17 g./cc. A strict sintering schedule is adhered to in order to control the density to within narrow limits, as material with too high a density may yield lamp filaments of insufficient stability.

The sintered bars are worked by swaging at 1,450–1,550° C., first by hand-feed, then continuously, to a size which has sufficient ductility for wire drawing. As the diameter gets smaller, temperatures are reduced to ensure that the material is worked below its recrystallisation temperature. During the swaging operation all rods are given an intermediate annealing treatment at about 2,000° C. Drawing, using tungsten carbide dies and colloidal graphite as lubricant, commences at about 2–3 mm. diameter, and at a temperature of about 1,000° C. At approximately 0·3–0·5 mm. diameter, diamond dies replace carbide dies. As the wire size decreases, the drawing temperatures are reduced from *c.* 1,000° C. to *c.* 450° C. for the finer sizes. During drawing, the wires are subjected to two intermediate annealing treatments, which are carried out in a continuous manner by either direct or indirect heating. In practice, wires may be drawn down to as low as 0·01 mm. diameter.

Great care is exercised during the swaging of tungsten to prevent splitting, and to ensure that the swaged rod is of sufficient ductility for subsequent drawing. The technique of drawing tungsten down to fine sizes depends upon the use of good dies, efficient lubrication and accurate drawing temperatures. This is to ensure that the wire at the final size is of uniform, round section, free from surface defects, of good mechanical properties, and of correct and uniform diameter along its length. These factors are essential to ensure the required dimensions and properties of the final coiled filaments.

Filament Stability

Wires at their final sizes are cleaned and then, in the case of filaments for coiled-coil lamps, coiled on primary and secondary molybdenum mandrels. The coiled work is given a heat-treatment at approximately 1,700° C. in a hydrogen atmosphere, which removes practically all internal strain introduced by the working processes. The molybdenum mandrel is removed by a dissolution process.

The use of tungsten as a lamp filament presents many metallurgical problems as, in contrast to most engineering metals and alloys, it is used above its recrystallisation temperature. Thus, to ensure stability of the filament, it is essential that very close control be exercised over the structure developed during the recrystallisation process. To produce a lamp of high efficiency, it is necessary that the filament should be substantially free from movement throughout its useful life. For example, Figs. 1*a* and 1*b* show two tungsten filaments which have been burnt in lamps for over 1,000 hours at *c.* 2,400° C., that is, at a temperature approximately equal to 70% of the melting temperature. In Fig. 1*a*, the filament has remained substantially unchanged, the light output has dropped only slightly over the period of test. The filament in Fig. 1*b*, however, shows substantial movement, and the light output has dropped more markedly. This instability may appear, in a general way, as shown in Fig. 1*b*, or in a more specific manner, such as localised distortion of turns or grain boundary movement.

As a result of a study of the structure of filaments throughout their burning life, it became evident that instability was, in the main, associated with recrystallisa-

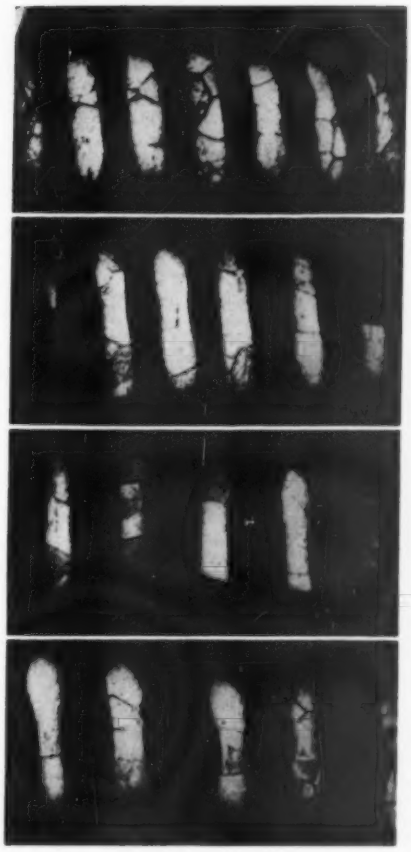


Fig. 2[a].—Progressive growth of pure tungsten throughout 600 hours at 2,400° C.

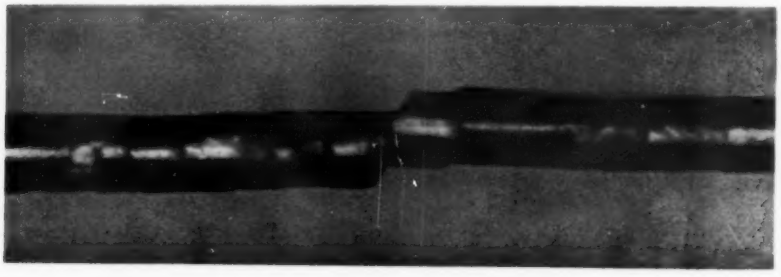


Fig. 3[a].—Offsetting in tungsten filament.

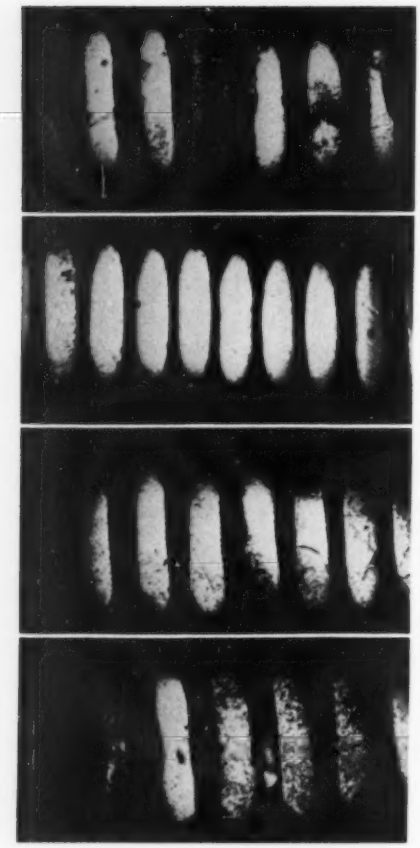


Fig. 4[6].—Stable exaggerated growth of tungsten containing traces of alkali and silica at 2,400° C.

tion and grain growth. For example, Fig. 2 illustrates the effect of heat-treatment at *c.* 2,400° C., on the structure of a very pure tungsten filament. It is of interest to note the crystal size after 1 minute, and the slight but progressive growth of these crystals throughout the period of 600 hours. A lamp filament with this type of structure would be unstable, owing to the progressive grain growth throughout its life. Furthermore, apart from this effect, trouble may arise owing to grain boundary movement, giving rise to offsetting, as shown in Fig. 3.

Thus, the problem resolves itself into the control of recrystallisation and grain growth. The method of approach was two-fold : (*i*) production of a fine-grained structure in which further growth is inhibited ; and (*ii*) production of a large-grained structure which remains stable from the inital lighting of a filament to the end of its life.

These types of controlled structures are obtained by additions of refractory oxides. To produce a stable fine-grained structure it is usual to add approximately 0·5% thoria, though this method is only partially successful ; on the other hand, exaggerated growth is obtained by the addition of traces of, for example, alkali, silica and alumina. Fig. 4 shows the stable exaggerated grain of tungsten containing traces of alkali and silica after heating for various times at *c.* 2,400° C. Of particular interest is the almost instantaneous completion of grain growth on first heating to this temperature : this results in a very stable filament.

Reference has been made above to offsetting, which is associated with the existence of crystal boundaries running across a section of wire, as seen in Fig. 3. To a certain extent, by suitably modifying the additions, some degree of control over the type of boundary may be maintained. For example, Fig. 5 shows the equiaxed structure of a pure tungsten wire, or a tungsten wire containing incorrect additions, after heat-treatment at *c.* 2,400° C. In contrast, when correct additions are made, the structure consists of elongated crystals having boundaries of the spliced or overlapping type as shown in Fig. 6. This type of structure is associated with good high temperature creep strength.

The reasons for the marked differences between these two types of structure are not fully understood. However, it illustrates the important role played by the presence of minute impurities in modifying the structure, as the amount of residual additive remaining after sintering the pressed tungsten bar at *c.* 3,000° C., appears to be less than 0·01%.

To improve still further the stability and uniformity of tungsten wires, research of both fundamental and

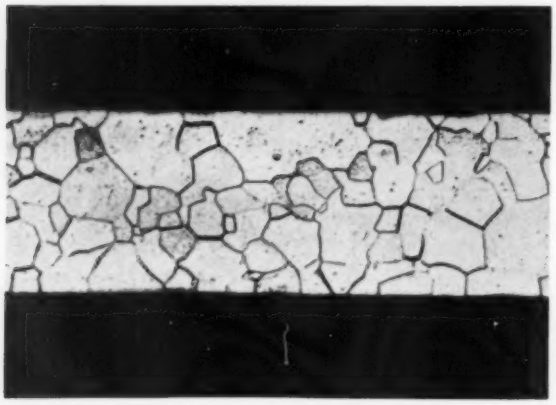


Fig. 5.—Equiaxed structure of pure tungsten wire after treatment at 2,400° C.

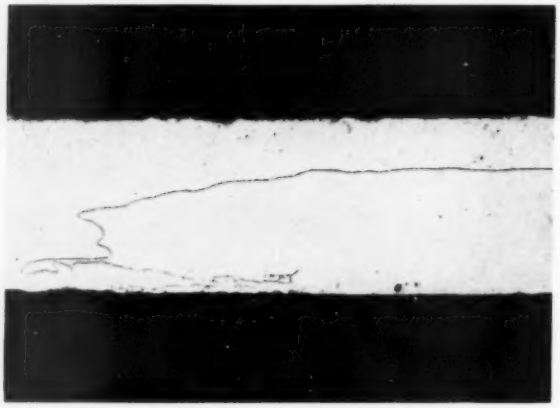


Fig. 6.—Structure showing overlapping boundaries in ' doped ' tungsten wire after treatment at 2,400° C.

development nature continues in this field, with the primary object of obtaining a better understanding of the effect of impurities on recrystallisation and grain growth, and so improving the general level of performance of tungsten filaments as a light source.

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5 Smithells, C. J., "Tungsten," 1952, Chapman and Hall, p. 31–32.
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Exhibition of High Temperature Refractories

SOME ten years ago, the limited refractory interests of the Morgan Crucible Co., Ltd., formed the basis for launching a new company, Morgan Refractories, Ltd., which today has three main lines: high temperature kilned refractory and insulating brick; refractory concrete and cements, sold under the trade name of Tri-Mor; and Battersea ware—a range of refractory products which includes Purox oxide refractories. Recent development work has resulted in laboratory ware in these highly refractory materials becoming available to a higher degree of purity, and in a wider range of shapes and sizes than has hitherto been possible. In opening a recent exhibition of this ware, Mr. A. L. Stock, Managing Director of The Morgan Crucible Co., Ltd., made the claim that Morgan Refractories lead the world in this field as regards quality, consistency and range, pointing out in support that the company entered the American market four years ago, and had now become the major supplier of high-grade ware, despite local manufacture and competition from other overseas countries.

It is not possible in the space available to deal fully with the items displayed at the exhibition, but reference may be made to one or two of special interest. These include the display of impervious and standard thoria ware—crucibles, tubes, boats, discs and blocks. Producing standard thoria to 99·9% purity is not unduly difficult, but the production of impervious thoria is a considerable technical achievement in view of the fact that no additions to the raw materials, of the kind normally used to provide a glassy phase, are made. Thoria crucibles may be used for melting titanium, hafnium, uranium, zirconium and silicon, and die-pressed or cast small pieces may be used as spacers in high temperature electric furnaces. This material is also available as furnace tubes and as high temperature pyrometer sheaths: the recommended maximum service temperature is 2,600° C.

View of a section of the Exhibition

The exhibits of Purox magnesia ware (98% minimum MgO) included crucibles, boats, discs, blocks, coarse textured ware, etc. Because of its comparatively poor mechanical strength at all stages of manufacture, magnesia is very difficult to fabricate, and the size range available today represents a marked advance on previous supplies. Magnesia ware finds application as thermal barrier discs, as crucibles for melting uranium, and as tubes, tiles and special shapes for high temperature furnaces: the recommended maximum service temperature is 2,400° C.

Purox recrystallised alumina contains a minimum of 99·7% Al_2O_3, and no additions of any kind are made, the physical characteristics of the material being entirely dependent on high temperature heat treatment. The recommended service temperature is 1,950° C., and the material is used for insulators, sheaths for platinum-rhodium thermocouples, high temperature furnace tubes, thermal barrier discs, and other small pressed parts. The central feature on the stand was a 7 in. diameter cylinder—the largest ever produced—and other exhibits included a 10 in. × 10 in. ball mill, large crucibles, complicated pressed components, etc.

In Purox stabilised zirconia ware—recommended maximum service temperature 2,500° C.—crucibles up to 50 cc. capacity are standard, and a restricted range of tubes and sheaths can be supplied to order. Typical applications include the melting of platinum, rhodium, iridium and tantalum.

Of specialised interst were the displays of forsterite, gadolinia/alumina, samaria/alumina and samaria/magnesia—all developed for their potentialities as materials for use in atomic reactors—and of thoria/ittria, spinel and ceria—produced in the search for new high temperature materials. Each of these materials is capable of further development.

Apart from these special high-lighted features, there were other large displays showing the entire range of recrystallised alumina ware—standard, non-standard, special and otherwise; sintered pure alumina tubes, crucibles and boats; foamed recrystallised alumina blocks; and thoria-lined recrystallised alumina crucibles.

Gas Dryer Order

AN order has recently been placed with the Dryer and Gas Plant Division of Birlec, Ltd., for two dryers to be supplied for the Italian nuclear power station under erection at Latina. This order brings to a total of eighteen the number of carbon dioxide dryers being supplied by Birlec, Ltd., for nuclear stations at Latina, Berkeley, Bradwell and Hunterston. Birlec has also supplied the air dryer installed at Dounreay in the fast breeder reactor vessel.

The B.C.I.R.A. Experimental Cupola Installation

View of the exterior of the cupola building with the pig casting machine in the foreground.

MOST of the iron for castings produced in the United Kingdom at the present time is melted in cupola furnaces, and, as far as can be foreseen, this situation is likely to persist for many years to come. The British Cast Iron Research Association (B.C.I.R.A.) has recognised for many years the desirability of installing an experimental cupola station to serve the needs of the industry in this country. It has also been considered that the installation should be on such a scale that the results would be applicable to industrial plant. Hitherto, the cost of installing and operating such a plant has been regarded as prohibitive, but, owing to the improved revenue of the Association in post-war years, the Council has found it possible to allocate a capital sum sufficient to finance the installation of a cupola plant which has been designed so that a very wide variety of problems of either long or short term nature may be investigated. The cupola may be operated with cold or hot blast, with or without water-cooling, and with acid, neutral or basic slags : the effects of design factors can also be investigated.

The Cupola

The cupola is of segmental construction, having interchangeable melting zone sections. Two melting zone sections have been provided, although the cupola may be adapted to operate with other designs if necessary. One of the melting zones is of conventional design with a parallel bore, to be used with a 9 in. thick refractory lining : the internal diameter of the cupola when lined is 30 in. The other melting zone section is conical in shape, widening towards the lower end, and is provided with four protruding water-cooled copper tuyeres. This melting zone section will be operated without a lining and the external surface will be extensively water-cooled. By its use, and with a suitable refractory in the wall, the cupola may be operated over a wide range of slag compositions from acid to highly basic. The protrusion distance of each tuyere can be adjusted so that the diameter of the cupola, measured across the faces of opposite tuyeres, may be varied between 30 in. and 42 in. The tuyeres of both melting zone sections are inclined downwards at an angle of 5° to the horizontal.

Both melting zone sections are fabricated from $\frac{7}{8}$ in. thick steel plate and are of welded construction, the welds being ground flush for water-cooling. Each is provided with a water-cooling spray ring at the top and collecting trough at the bottom. The cooling water for the cupola shell, and also for the copper tuyeres when the conical melting zone is used, is recirculated. It is pumped to the cupola shell and tuyeres from a cooling tower : two pumps are provided, one to serve as a stand-by with a pressure switch in the delivery line so that, in the event of one pump failing, the stand-by pump automatically cuts-in. Coloured lights indicate which of the pumps is operating, and a different switch connected across the impulse lines of an orifice plate flow meter in the supply line operates a klaxon hooter in the event of failure of both pumps. If both pumps fail, the supply lines to the cupola shell tuyeres can be fed directly from the mains. The return water is piped from the water-collecting trough at the base of the melting zone and returned to a buffer tank, from where it is pumped to the top of the cooling tower.

The temperature of the water flowing to the cupola and returning from it is measured by two nickel resistance thermometers and recorded by an instrument in the instrument room. These temperatures are also measured by mercury-in-glass thermometers in the supply and return pipe lines. The total water flow to the cupola shell and tuyeres is measured by means of an orifice plate in the main supply line. The latter feeds a manifold from which separate lines supply water to the spray ring and, when the conical melting zone is used, to each tuyere. Each supply line has its own control valve, and the flow in each is measured by means of an orifice plate and indicated on meters situated beneath the control valves. The temperature of the water leaving each copper tuyere is also indicated by a mercury-in-glass thermometer.

Each melting zone section is provided with its own well section to which it is bolted through flanges. The well sections are made of $\frac{1}{2}$ in. thick mild steel plate and are provided with a fettling hole, continuous front slagging box, and an emergency slag spout. The depth

of the well in each case can be varied by altering the height of the sand bottom. The tapping box can be bolted to the well at different heights and the taphole can be set accordingly. It is thus possible to vary the depth of the well by 18 in.

The windbelt is circular in cross-section, and is suspended from the underside of the charging platform. It is internally lined with a 4 in. thickness of insulating refractory cement, and the lined internal diameter is 27 in. The downcomers, which are internally insulated with a 3 in. thickness of insulating refractory cement, are flanged and bolted through matching flanges to the tuyere elbows. When changing the melting zones, the tuyere elbows can be removed with the appropriate melting zone section. The tuyere elbows for the replacement section can be fitted after this section has been positioned.

In order that the melting zone and well sections can be removed and replaced, the cupola is so constructed that the lower section, below charging platform level, can telescope inside the upper section. The upper section is supported on the charging platform, independently of the lower section, and is fitted with its own sole plate with suitable gusset plates to the shell. The lower section of the cupola can be lifted by means of four jacks situated at equal intervals around the cupola on the charging platform. These jacks operate on four lifting pads which are attached to the top portion of the lower cupola section, and which protrude through openings in the shell of the upper section. When the lower section of the cupola is raised on the jacks, the cupola supporting columns can be removed.

Each melting zone is provided with two lifting attachments diametrically opposite each other. A two-sheaved pulley block is fixed to each attachment, and a three-sheaved block is fixed to the underside of the charging platform directly above each of the two-sheaved blocks. Wire ropes pass around the pulley systems to an electric reversing winch, driven by a 5 h.p. motor which is supported on the underside of the charging platform. The ropes are pulled up tight and the flange securing the melting zone to the cupola shell is unbolted. The melting zone and well are then lowered on to a trolley by unwinding the winch. The melting zone and well can then be removed and replaced by reversing the procedure for dismantling.

The cupola is provided with a wet spark arrester of B.C.I.R.A. design, the water supply to which is recirculated, the water tank and pump being situated on the charging platform. The flow of water to the arrester is measured by means of an orifice plate and indicating meter and can be controlled by a valve. A differential pressure switch is connected across the impulse lines of the meter and operates a klaxon hooter on failure of the pump.

Air Supply and Heating

The blowing equipment consists of two centrifugal fans, which, by means of a suitable arrangement of ducting and dampers, may be used either singly or in series. The larger of the fans is driven by a 50 h.p. motor and can deliver 3,000 cu. ft./min. of air at an outlet pressure of 58 in. W.G. The smaller fan is driven by a 30 h.p. motor and can deliver 3,000 cu. ft./min. at 30 in. W.G. When both fans are running in series, they will deliver 3,000 cu. ft./min. at a pressure of approximately 90 in. W.G.

The air flow to the cupola is measured by means of an orifice plate situated in the inlet duct to the blowers, which is 14 in. in diameter and approximately 25 ft. in length. The flow is recorded on a Foxboro-Yoxall air weight controller-recorder, which is equipped with integral correction gear for changes of temperature and pressure of the air in the inlet pipe, so that a constant weight of air is delivered to the cupola, the controller operating a butterfly valve on the inlet side of the fan.

In specifying the maximum duty conditions for the air heater, it was considered desirable to obtain the highest air preheat consistent with freedom from premature failure and air leakage, bearing in mind the limitations imposed by the heat resisting materials available at the present day, and having due regard to cost. It was considered that the highest preheat likely to be obtained at a reasonable economic cost by the use of a metallic heat exchanger was 800° C., if early failure of the heat exchange elements were to be avoided. This figure was therefore specified for the plant.

The heater is a combined radiation and convection heater directly fired by oil. The radiation, or INKA, heater, is of Swedish origin, now made under licence in this country. The heat exchange unit consists of 72 tubes 8 ft. 2 in. long, 1·7 in. outside diameter by 0·13 in. thick, made from ferritic steel having a chromium content of 27%. The tubes are welded into an inlet ring of rectangular section and an outlet ring of circular section. The inlet ring is constructed from 0·2 in. thick steel plate having a chromium content of 14%, and the outlet ring from 0·16 in. steel plate having a chromium content of 24%. The tubes are arranged in the form of a squirrel cage, the diameter of the tube ring being approximately 5 ft. 8 in.

The tube cage and air main rings are housed in a refractory-lined steel shell approximately 9 ft. 5 in. inside diameter, supported from ground level by eight steel joist supporting legs. A refractory conical shaped combustion chamber encased in mild steel is mounted at the top of the heater. The refractory lining of the heater shell consists of a 9 in. thick first-quality firebrick backed by 4½ in. thick insulating brick.

The heating gases are generated by means of a self-proportioning oil burner, the air for combustion being provided by means of a motor-driven fan. The burner is designed to handle an oil rate of between 200 and 20 lb./hr., and the oil and total air required for combustion pass through the nozzles. To enable it to operate over the above range of oil rates, the burner is provided with a modified inner assembly which can be used to extend the range of the normal assembly when required. The oil is fed by gravity to the oil pumps from an overhead tank : two oil pumps are provided, one to act as a stand-by, and the oil flow from the pumps to the burner is measured by a Kent CM oil meter. The combustion air flow is measured by means of an orifice plate in the supply line, and the flow is indicated on an inclined manometer gauge. Both the oil and air flow meters are located in the blower house.

A photo-electric flame failure device is mounted on the burner platform. The photocell head views the flame through a small window in the burner platform, and is connected through an amplifier to a solenoid valve in the oil supply line. On extinction of the flame, the solenoid valve cuts off the oil supply to the burner. The solenoid valve is also connected to the circuit of the combustion air fan, so that it closes if the combustion air fan fails,

thus shutting off the oil supply to the burner. The combustion air fan is connected into the circuit of the main cupola air blowers so that, on failure of these blowers, the combustion air fan is automatically tripped out and this in turn cuts off the oil supply.

The waste gases leave at the base of the radiation heater through a mild steel refractory lined duct and pass via an underground brick flue to the entrance of the convection heater. The convection heater consists of 24 needle tubes, approximately 4 ft. 6 in. in length, disposed horizontally in two groups. The waste gas passes vertically upwards on the outside of the tubes in a single pass, and thence through a waste gas hood to a 50 ft. high chimney.

Each group of tubes has four tubes in the width and is three-high in the direction of flow of the waste gas. All the tubes have extended needle surfaces on both waste gas and air sides, and those tubes in the hottest two rows are cast from 30–35% chrome alloy iron. Each tube is fitted at both ends with an extension sleeve which passes through a tube plate to which the sleeves are welded in order to provide flexibility for expansion and an air-tight construction. The tubes are supported in a cast iron and mild steel framework, built into the surrounding brickwork setting and positioned by tie rods. The intermediate horizontal framework members are protected from the hot gases by means of pre-cast firebrick protection blocks. Woven asbestos rope is caulked between the tube flanges and framework to allow for free expansion while maintaining a tight joint between the waste gas and atmosphere.

The heating unit is housed in a brickwork setting constructed in 9 in. thick firebricks backed by 4½ in. thick insulating bricks. The brickwork is encased in a mild steel plate casing provided with the necessary buckstays and ties.

The convection section is arranged for contra flow of the air and waste gas. The air from the blowers enters the upper group of tubes first and then passes through the lower group before passing to the radiation heater.

The ducting is bolted to the periphery of the end tube plates and comprises mild steel inlet, return, and outlet connections. The hot air ducts have cleats welded to the external surface at intervals to provide anchorage for lagging. A corrugated expansion joint is provided in the ducting connecting the two heaters.

The hot air from the convection section enters the upper collector ring of the radiation heater, and passes downwards through the tubes in parallel flow to the waste gas. The air then passes through the lower collector ring to the outlet, which is constructed in 24% chromium steel. The outlet is connected to a horizontal expansion piece, both the outlet and expansion piece being lagged externally. The air passes from the expansion piece into a vertical mild steel chimney, lined with insulating refractory. This chimney is provided with a spring-loaded flap valve at the top and an outlet to the cupola windbelt, the connecting main between the chimney and cupola windbelt being provided with an isolating gate valve. When this valve is closed and the chimney valve open, the blast can be blown to atmosphere. Thus the cupola can be operated at a required blast temperature from the beginning of melting, and the blast can be maintained at temperature in the event of shut downs.

The design performance data for the heater at maximum duty are as follows :

Radiation Section :	
Waste gas inlet temperature	1,450° C.
Waste gas outlet temperature	1,000° C.
Quantity of air heated	90,000 cu. ft./hr. (N.T.P.)
Air inlet temperature	350° C.
Air outlet temperature	800° C.
Approximate fuel consumption at burner	200 lb./hour.
Assumed C.V. of fuel oil	18,000 B.Th.U./lb.
Convection Section :	
Waste gas inlet temperature	1,000° C.
Waste gas outlet temperature	450° C.
Quantity of air heated	90,000 cu. ft./hr. (N.T.P.)
Air inlet temperature	15° C.
Air outlet temperature	350° C.

There is also a cold blast main which by-passes the heater and enters the vent chimney. When blast temperatures lower than 800° C. are required, particularly when blast volumes in excess of 90,000 cu. ft./hr. are used, the air from the heater may be blended with cold air from the by-pass : mixing is effected in the vent chimney. The air outlet temperature of the radiation heater is controlled by a temperature controller-recorder from a thermocouple in the outlet duct of the heater. The out-of-balance signal is transmitted pneumatically to a power cylinder connected to the single lever control on the self-proportioning oil burner. The temperature of the blast is controlled by a temperature controller-recorder from a thermocouple in the hot blast main connecting the vent chimney to the cupola windbelt. The out-of-balance signal from the instrument is transmitted pneumatically to another power cylinder operating a butterfly valve in the cold blast main. Thus, the outlet temperature of the radiation heater is automatically maintained at a constant value and the blast temperature is maintained constant by controlling the relative volumes of air passing through the heater and cold blast by-pass. The controller operating from the thermocouple in the heater outlet is also connected to a klaxon hooter which operates if the air outlet temperature exceeds 800° C., causing overheating of the tubes.

Charging Equipment

The cupola is charged by means of a single flap drop-bottom bucket, which is filled at ground level and raised by a 2 ton lift capacity crane carried on an overhead dual track runway supported by two steel frames on the charging platform. The crane has a vertical hoisting speed of 60 ft./min. and a cross-traverse speed of 50 ft./min. Operation of the hoist, traverse, retract and lower motions is controlled by push-buttons, duplicate sets being provided at ground level and at charging platform level, so that the crane may be operated from either of these stations. Positive end stops and limits switches controlling the crane movements are provided.

The charging bucket has a single bottom door, hinged one side, with a locking catch on the other side. A tripping arm is mounted on the bucket, with a roller to strike a block in the cupola to release the bottom door. On the retract motion of the crane, a roller mounted on the underside of the bottom door engages on a curved steel plate fixed to the base of the charging hole and automatically closes the bucket. The bucket is suspended by fixed hanger bars with a locked safety hook on the crane rope. A trip switch which operates on the cross-traverse motion of the crane is connected to a time recorder in the instrument room, so that the time at which each charge enters the cupola is recorded.

The crane cross-traverse motion circuit is connected

to the cupola charge level indicator, so that the crane will not traverse until the charges have fallen to a safe level, preventing the risk of materials being trapped by, or trapping, the charging bucket. The charge level indicator consists of a 40 millicurie Cobalt 60 gamma ray source enclosed in a lead box with walls 2 in. thick. This is located at one side of the cupola, 2 ft. 6 in. below the level of the charging door sill. Diametrically opposite is a gamma detector provided with a relay, which, when the rays pass unhindered to the detector, closes the cross-traverse circuit of the charging crane so that the cupola can be charged by depressing the push-button, and at the same time a green light visible to the charging operator is automatically switched on. When the charge level is above the gamma ray source, the rays are absorbed and the relay breaks the cross-traverse circuit of the crane so that the crane will not operate when the push-button is depressed. At the same time a red light is automatically switched on.

Stocks for a day's melting are contained in six steel-plated bunkers at the rear of the cupola. An overhead dual trackway carrying a dial weigher and skip traverses the length of the bunkers, and charges are made up in the skip, materials being transferred directly from the bunkers by hand. The dial weigher has a capacity of 10 cwt. and is graduated in 2 lb. divisions. The skip is discharged into the charging bucket which sits in a sunken pit in the floor.

The melting stock, coke and fluxes are charged directly into the bunkers from the stockyard by means of a 2 ton lift capacity electric overhead travelling crane which spans the stockyard and can operate with either magnet or hook. The crane has a run of 120 ft., a span of 47 ft. 6 in., and is cabin-controlled.

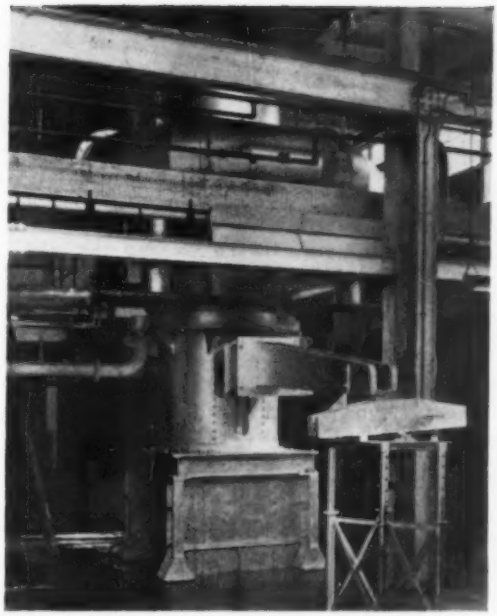
Molten Metal Disposal

The molten metal from the cupola can be diverted to either of two ladles by means of a tilting spout mounted just beneath the end of the cupola spout. When one ladle has been filled, the spout is tilted so that the metal stream is diverted to the second ladle. The full ladle is transferred by overhead travelling crane to a pig casting machine, where it is emptied into a pouring pot provided with a launder which feeds the pig casting machine.

The pig casting machine has a maximum output of 7½ tons/hr., and is designed to cast metal pigs of 55 lb. weight, each pig having two notches so that it can easily be broken in equal pieces.

The chain to which the moulds are attached is capable of running at four independent speeds between 1 and 4 ft./min., and is powered through reduction gear by a 5 h.p. 1,000 r.p.m. motor. The reduction gear is coupled to the electric motor and machine-driving shaft by means of flexible couplings. The head shaft is carried in heavy steel bearings with gun metal liners, and has cast iron main chain sprockets keyed on. On the extreme end of the head shaft is a knocker gear sprocket which engages a roller connected to links which operate a knocker hammer for loosening the ingots from the moulds. The tail sprockets for the chain are identical with the head end sprockets, with the exception that one is bushed and located on the shaft to allow for expansion. The tail shaft is designed to run free in bushed blocks carried in tension gear brackets fitted with screws and slides to allow for adjustment of tension in the chain.

After pouring, the moulds are cooled naturally for a certain travelling length, and are then sprayed with water on the upper section to cool the pigs finally, and to avoid overheating the moulds. Water is supplied to a pipe made in two sections, with a separate water supply to each controlled by valves. The pipe is perforated on the underside with a number of small holes from which the water issues as a series of sprays onto the moulds. The ingots are finally ejected and fall down chutes to be collected in steel stillages which are taken to the stockyard by an elevating platform auto-truck.



View of the base of the new cupola

The emptied moulds are sprayed with either a lime or blacking slurry, the mixing tank being located beneath the pig casting machine. The slurry is pumped from the tank by a pump driven by a ¾ h.p., 720 r.p.m. motor: the return line from the pump feeds the sprays and another pipe, perforated with a series of holes and submerged at the bottom of the tank, which serves to agitate the slurry. A number of gas jets fed from a manifold are mounted on the underside of the machine to preheat the moulds prior to pouring.

Instruments

Reference has already been made to the functions of most of the instruments. The following instruments are located in the instrument room:

Controller-Recorders

(1) Air flow to cupola.
(2) Air temperature, radiation heater outlet.
(3) Air temperature, hot blast main.

Recorders

(1) Blast pressure, cupola windbelt.
(2) Metal temperature, cupola spout.
(3) Charging times.
(4) Water temperature, (*a*) to, and (*b*) from, cupola shell and tuyeres.
(5) Gas temperature, (*a*) outlet of radiation heater, (*b*) outlet of convection heater.
Air temperature, (*a*) outlet of convection heater, (*b*) outlet of radiation heater, (*c*) cupola windbelt.
(6) Gas analysis (CO, CO_2 and H_2), cupola top gas.

The following water flow gauges are located beneath the control valves on the ground floor of the cupola building :

(1) Water flow to cupola shell and tuyeres.
(2) Water flow to cupola spray ring.
(3) Water flow to cupola tuyere No. 1.
(4) Water flow to cupola tuyere No. 2.
(5) Water flow to cupola tuyere No. 3.
(6) Water flow to cupola tuyere No. 4.

A further gauge measuring the flow of water to the spark arrester is located on the charging platform.

Located in the blower house are the following instruments :

(1) Oil flow meter.
(2) Combustion air flow meter.

Mercury-in-glass thermometers are inserted in the water supply line to, and return from, the cupola shell and tuyeres. Thermometers can also be inserted in the outlet pipes of the copper tuyeres.

The portable instruments available include a suction pyrometer for measurement of cupola top gas temperatures ; Orsat-Lunge gas analysis apparatus for the determination of CO_2, CO, O_2 and H_2 in the cupola top gas ; and hygrometers for the determination of the moisture content of the blast.

Contractors

The installation of the plant was only made possible by the very willing co-operation and generosity of the main contractors, Newton Chambers and Co., Ltd., who were responsible for the whole of the scheme, with the assistance of The Constructional Engineering Co., Ltd. The equipment involves several ambitious features, unusual in present industrial plant, and the Association has expressed itself as fortunate in having the assistance of these companies in completing the design.

The considerable structural modifications to the existing foundry and the preparation of the site and foundations, which involved much improvisation, were carried out under the supervision of the Association's architect, Mr. F. J. Meeson.

Aluminium for Sub-Zero Methane

HISTORY was made on February 20th this year when the tanker *Methane Pioneer*, specially converted for the purpose, arrived off Canvey Island with the first cargo of liquid methane brought from Gulf of Mexico. This was an experimental project undertaken by the Gas Council with the co-operation of the aluminium industry, and its success means the certainty that new supplies of cheap fuel can be brought to British homes and factories.

On Thursday, May 7th, at the British Council Theatre, Hanover Street, W.1. the film " Aluminium for Sub-Zero Methane " made by The Aluminium Development Association, had its preview before a selected audience of the industries and authorities chiefly concerned. The film opens with a clear indication of the significance of liquefying methane gas so as to occupy only 1/600th of its volume—thus becoming transportable in containers by sea, provided suitable containers could be made. The liquid is extremely cold and creates peculiar difficulties for some container materials. The film briefly refers to low temperature tests on certain aluminium alloys which were the subject of recent discussion at the Institute of Welding. Low temperature laboratory work was undertaken by several Member Companies of the Association by Lloyds Register of Shipping, and four Papers describing the work were published in the *British Welding Journal* and are now available as A.D.A. Reprint 77. As a result of these exacting researches, five 400-ton capacity aluminium alloy tanks were fitted into *Methane Pioneer* which the film shows arriving off Canvey Island.

The film is largely concerned with the fabrication of two 1,000 ton aluminium alloy storage tanks on Canvey Island (one by The A.P.V. Co., Ltd., and the other by Whessoe, Ltd.) and of the two 2,000 ft. aluminium alloy pipe lines running from tanks to jetty. Welding by inert-gas metal arc was nearly all done on site, and contributes substantially to the story of what is probably the largest use of aluminium for storage vessels in this country. An important aspect, clearly brought out by the film, is the care taken by means of frequent testing and inspection to avoid risk of leakage of liquid methane, and a special feature of the whole project was 100% radiographic inspection of welded joints.

This is a 16 mm. colour film, with commentary, which runs for 17½ minutes. It is available on loan to technical schools and colleges, works training centres and other interested bodies having the necessary facilities. Enquiries should be addressed to the Aluminium Development Association, 33, Grosvenor Street, London, W.1.

Expansion of Concast A.G.

THE UNITED STEEL COS., LTD., have become shareholders in Concast A.G., of Zurich, and Mr. G. N. F. Wingate, Director and General Manager of Distington Engineering Co., a United Steel subsidiary, has joined the Concast board. At the same time, the Schloemann Company of Dusseldorf, and the Compagnie des Forges et Acieries de la Marine et de St. Etienne S.A., Paris, have become shareholders in Concast A.G., whose new board members also include Dr. h.c. G. Losch, of Krefeld, Dr. B. Knapp, of Dusseldorf, and M. Henri Malcor, of Paris, under the chairmanship of Mr. Irving Rossi, of New York.

Concast is the leading company in the field of continuous casting of metals, especially of steel, and these developments reflect the company's decision to expand in order to meet a growing volume of business. Having already successfully applied continuous casting to the production of steel slabs up to 36 in. wide, the company is now constructing two wide slab machines, one for Yawata Iron and Steel Co., Ltd., of Tokyo, and the other for Ste. des Fonderies de Pont-a-Mousson in France. These slabs will be up to 50 in. wide and from 4 to 8 in. thick. Concast is also pioneering the development of the horizontal continuous casting of steel. Two horizontal Concast/Tessman machines for the casting of steel have been constructed, and first tests look very promising ; a third experimental machine is soon to be put into operation in Europe. This process has already been proved commercially in the production of non-ferrous metal billets.

Aluminized Steel—Its Properties and Uses

By K. G. Coburn

Supervising Research Metallurgist, Armco Steel Corporation, Middletown, Ohio.

The hot-dip process for the production of aluminium-coated steel sheet and strip was first introduced in 1939, and the product is now well established for applications where heat or corrosion resistance is required. A brief account is given of the properties, fabrication, and uses of aluminized steel.

ALUMINIUM-COATED steel is well established in many product fields where superior heat and corrosion resistance is required. Good heat reflectivity and the strength of carbon steel are companion properties that widen the scope of application. Aluminium coatings may be applied to steel by spraying, electroplating, calorizing, cladding or hot dipping methods. Of these, only the hot-dip process has been developed commercially for sheet and coils over a broad range of gauge and size. This was accomplished by Armco Steel Corporation in 1939 when aluminized steel was first introduced.

The material is produced by a continuous process, which utilizes similar equipment to that required for continuous galvanizing by the Armco method. This ensures a tightly adherent coating bonded to the steel base by an iron-aluminium alloy. Good coating uniformity is obtained on both sides of the sheet.

The product possesses many of the surface characteristics of aluminium, and is regularly supplied with a satin-like matt finish that is free of spangle. For applications where a brighter appearance is required, an extra smooth finish can be obtained by rolling on a bright temper mill. Composition of the protective coating is closely controlled, and the aluminium coating may be applied to a wide range of base-metal analyses, including mild, copper-bearing and low-alloy high-strength steels. Uniformity of base-metal properties is assured by continuous processing, which combines annealing with the coating operation. The standard product is designated as commercial quality, with a drawing grade available for more difficult parts.

Aluminized steel is manufactured in two grades of coating analysis. The first of these is known as Type 1, and has a silicon-aluminium alloy coating best suited for high temperature service and many applications where a combination of heat and corrosion is involved. The companion grade is identified as Type 2, and its coating is applied from a bath of commercially pure aluminium. The notable property of Type 2 is its excellent resistance to atmospheric corrosion. This makes it an ideal metal for a wide range of outdoor applications. Both types have good heat reflectivity.

Properties of the Coating

Coating Weight—The total weight of aluminium applied to both sides of the Type 1 sheet is approximately 0·5 oz./sq. ft., which provides a coating thickness of about 0·001 in. of aluminium on each side. This is approximately equivalent in thickness to a 1·25 oz./sq. ft. coating of zinc. Coating weight of the more atmospheric corrosion resistant Type 2 grade is approximately 1·0 oz./sq. ft., or 0·002 in. of aluminium on each side.

The difference in coating weight is due largely to the effect of silicon, which alters the surface oxide characteristics of the coating bath, causing an apparent change

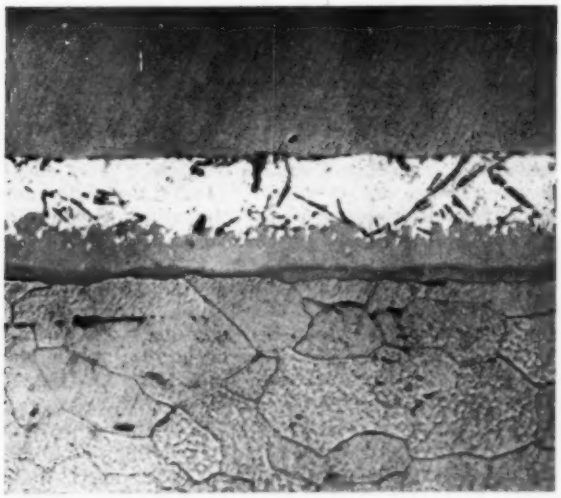


Fig. 1.—Microstructure of coating on Type 1 aluminized steel. × 1,000.

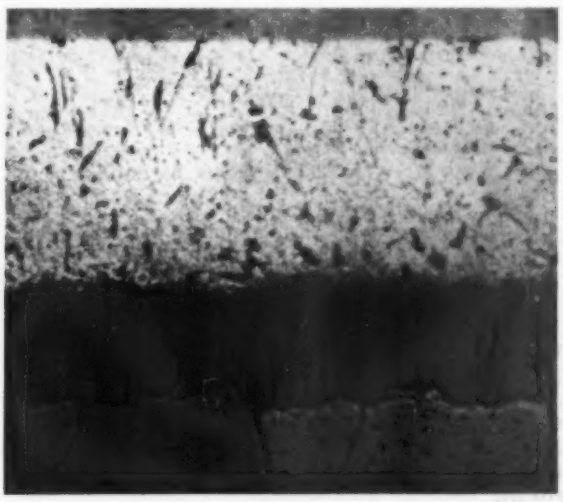


Fig. 2.—Microstructure of coating on Type 2 aluminized steel. × 1,000.

in the viscosity of aluminium. This effect, combined with inhibition of growth of the iron-aluminium alloy layer, results in thinner coatings. As the thickness of the iron-aluminium bonding layer is reduced, the ability of the coating to withstand deformation without peeling is significantly improved. Precise control of strip and coating bath temperature is also important to control of alloy thickness.

Coating Structure—A typical microstructure of a silicon-aluminium coating applied by the Armco method is shown in Fig. 1. The dark grey acicular needles in the outer coating layer are a silicon-rich constituent. Whilst these needles may contain a small percentage of iron and aluminium, they are principally silicon. The balance of the outer layer is aluminium solid solution with small dispersed islands of an iron-aluminium constituent. The two layers closest to the steel base represent separate strata of iron-aluminium-silicon alloy. Iron content of these layers has not been determined independently, but total iron averages 33·5%.

Structure of the heavier non-alloyed coating on Type 2, is shown in Fig. 2. In the absence of silicon, plates and stringers in the outer layer consist only of an iron-aluminium constituent in aluminium solid solution. The bonding layer next to the base metal is composed of iron-aluminium constituents containing about 45% iron. The bonding layer develops greater thickness and contains higher iron than when effective amounts of silicon are present in the coating.

X-ray examination of the alloy of both types of aluminized coating has been made after chemical stripping to remove the outer aluminium. This showed the alloy layer of both grades contained FeAl as one of the principal constituents and Fe_3Al in lesser amounts. No $FeAl_3$ or Fe_2Al_7 were found in either of the two materials. According to the equilibrium diagram $FeAl_3$ and Fe_2Al_5 might be expected at 33·5% and 45% iron, respectively. These X-ray results may support the theory that certain phase types are not stable at lower temperatures.

Physical and Mechanical Properties—The properties shown below are typical of both types of aluminium-coated steel with a low carbon steel base.

Tensile Strength (lb./sq. in.)	55,000
(tons/sq. in.)	24·5
Yield Strength (lb./sq. in.)	40,000
(tons/sq. in.)	17·9
Elongation (% on 2 in.)	28
Hardness (Rockwell B)	66
Modulus of Elasticity (lb./sq. in.)	29,000,000
Coefficient of Thermal Expansion	
(10^{-6} in./in./° F.)	6·7
(10^{-6} in./in./° C.)	12·03

These strength properties of a steel base combined with the durability of an aluminium coating usually permit the use of a thinner sheet than would be possible with a solid aluminium sheet.

Heat Resistance and Reflectivity

The heat resisting properties of aluminium coatings have been known for many years. Aluminium coatings have been applied after fabrication, by metal spraying or by the calorizing process, to obtain scale resistance on ferrous articles subjected to elevated temperatures. However, aluminium-coated sheets have widened the field of application to many articles for which other coating methods were unsuitable; furthermore, they have lowered costs by permitting fabrication of a pre-coated sheet.

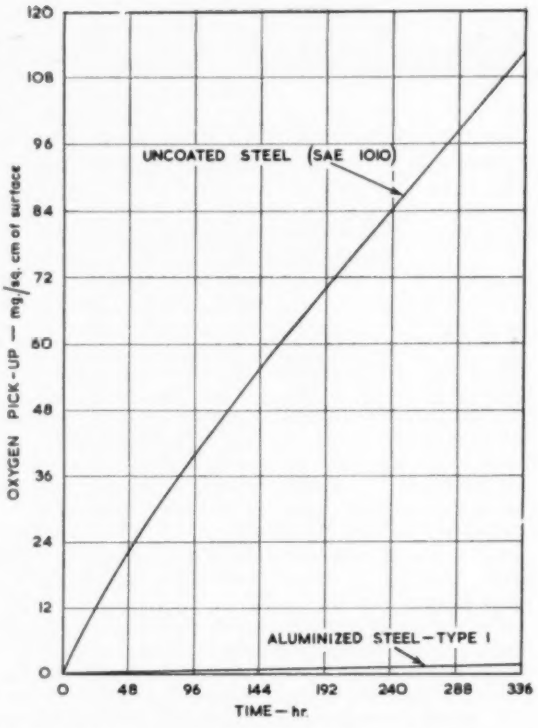


Fig. 3.—Weight increase due to oxidation. Comparison of rates for low carbon uncoated steel and Type 1 aluminized steel exposed in air at 1,250° F. (677° C.)

Type 1 will withstand temperatures up to 900° F. (482° C.) without discolouration, and up to 1,250° F. (677° C.) without destructive scaling. Above 900° F. (482° C.) the coating begins to alloy with the steel base, forming a tight refractory layer of iron-aluminium alloy. Once formed, the dark grey alloy will not revert to its original bright appearance. The iron-aluminium alloy has excellent heat resistance and extends the maximum service temperature beyond the melting point of aluminium. Fig. 3 compares the oxidation resistance of Type 1 with that of unprotected steel exposed at 1,250° F. (677° C.). The rate at which materials increase in weight by oxygen pick-up is an indication of their service life: after 336 hours at 1,250° F. (677° C.) the weight increase of unprotected steel was 56 times that of aluminium coated. The unalloyed coating of Type 2 gives equal heat resistance up to 900° F. (482° C.), but is not recommended for use above this temperature. Both types retain half their normal mechanical strength at 900° F. (482° C.). This has reduced the extent of structural damage resulting from accidental fires.

At temperatures up to 900° F. (482° C.) aluminium-coated steel will reflect approximately 80% of incident radiant heat. This characteristic of the coating is retained after use because of its resistance to detrimental oxidation and discolouration by heat. The advantage of this property is seen in such applications as roofing sheets, which reflect solar heat in summer and retain generated heat in winter. In such a typical use as oven liners, advantages over other types of materials consist of faster heating rate, higher maximum temperature, and less heat input at operating temperature.

Corrosion Resistance

Atmospheric corrosion resistance of silicon-aluminium coatings is inferior to that of unalloyed aluminium coatings, and the silicon-bearing type is not usually recommended for atmospheric service. The Type 1 product is primarily a heat resistant grade that gives good service in many applications requiring combined heat and corrosion resistance. This application is typified by automobile mufflers, where heat resistance is required in combination with protection against corrosive condensates that often form during intermittent cooling. Tests conducted for the American Gas Association have shown the Type 1 coating to be decidedly resistant to corrosion by the combustion products from high-sulphur natural gas.

The heavier unalloyed Type 2 coating is best suited for service where resistance to atmospheric corrosion is the primary consideration. On the basis of atmospheric exposure results to date, it is estimated that coating life in a mild industrial atmosphere will be at least three times that of commercial zinc coatings. Type 2 material has been exposed in the atmosphere at Middletown, Ohio, for nineteen years, and the coating is still intact. Galvanized sheet with a 1 oz./sq. ft. coating was exposed at the same time, and the zinc coating failed after seven years, the base-metal surface being 30% red-rusted at the end of twelve years. Appearance of the Type 2 surface after weathering is similar to that of solid aluminium sheet. Samples of both exposed side by side for eight years in an industrial atmosphere cannot be told apart.

When exposed to the atmosphere, aluminium acquires a protective surface film. This sometimes causes the aluminium coating to become passive ; so that galvanic protection is not provided at sheared edges. As a result, edge rust will generally appear after a short period of exposure, the amount depending on the type of atmosphere and the thickness of the sheet. Samples exposed to the atmosphere for nineteen years show no undercutting of the coating, and no bleeding of rust from the edge.

Precautions must be taken to avoid water accumulation between stacked sheets or coil laps. Under such conditions, all aluminium surfaces are subject to water staining. This detracts from the appearance and in severe cases may reduce corrosion protection. Moisture may enter as a result of damage to the protective cover during shipment, or by condensation resulting from a rapid change in temperature. Aluminized steel is usually surface treated or oiled to resist water staining, but, like zinc-coated sheets, the surfaces should be separated and dried if they become wet while in a stack or coil.

Fabrication

Coating Adherence—Type 1 aluminized steel will withstand moderate forming, drawing and spinning operations without flaking or peeling of the coating. The material can be bent through 180° over a diameter equal to twice its thickness without loss of bond between coating and base-metal. However, more liberal bend radii are recommended when equipment will be operating at temperatures above 900° F. (482° C.), particularly under conditions of cyclic heating and cooling. Liberal radii prevent crazing of the coating, and ensure maximum heat and corrosion resistance at formed areas.

Type 2 aluminized steel will withstand moderate brake or roll forming operations, and also can be bent 180° over a diameter equal to twice its thickness without separation of the coating. The material can be spun or embossed, but is not suitable for drawing operations.

Aluminium coatings on steel have better adherence when drawn in tension than if deformed under compression. When stressed in tension the iron-aluminium phase next to the base metal develops vertical cracks without losing bonding to the base metal. Under severe compression, shearing stresses develop at the alloy base-metal interface which cause horizontal cracks in the alloy and separation of the coating from the steel.

Joining—Any of the standard methods of welding can be used to join aluminium-coated steel. Good joint strength is obtained when welding techniques are adapted to the properties of the material. Spot or seam resistance welding is recommended wherever practical, because less damage is done to the protective coating in the weld area. However, satisfactory welds are obtained with all types of fusion welding. Care must be exercised in controlling the aluminium oxide on the surface of the coating, as well as that formed during welding, or it will tend to prevent steel-to-steel contact and increase weld porosity. This is done by using the proper welding flux or an inert gas shield. After cleaning, fusion welds are usually repaired by metallizing or covering with aluminium paint.

Brazed joints can be made by using silicon-bronze rods. In this case the joint is between coated surfaces and should be used only when the strength of a steel-to-steel joint is not required. Soldering aluminium-coated steel presents the same problems as soldering aluminium, and no practical method has yet been developed.

Painting and Finishing—In most applications the surface of aluminium-coated steel is satisfactory and painting is not required. In special cases where the material is to be painted, the procedure varies with the condition of the aluminium surface. Although untreated aluminium surfaces have better paint-holding qualities than galvanized steel, it is advisable to Bonderize untreated aluminium coatings for prolonged paint life.

Type 1 is usually supplied as oiled but not surface treated. On the other hand Type 2 is normally supplied with a chromate surface treatment that ensures good paint life without further chemical preparation.

If a polished surface is desired for appearance or maximum heat reflectivity, this may be obtained by buffing an extra-smooth aluminized surface supplied for this purpose.

Uses

The Type 1 heat resistant grade is being widely used in kitchen range and laundry appliances, heat exchanger tubes, water heater and oven liners, element retainers and baffles, reflector plates, and automobile mufflers and tail pipes. A more recent use has been as a steel base for porcelain enamelling. Fabricated parts have been porcelain enamelled for curtain wall panels, outdoor signs and chalk boards. Low temperature enamels are used, and these are applied generally to the exposed side only. There is no flatness problem after enamelling, owing to the high temperature strength of aluminium-coated steel sheet. Corrosion protection of the aluminium coating on the back side is not affected at firing temperatures recommended for low temperature enamels.

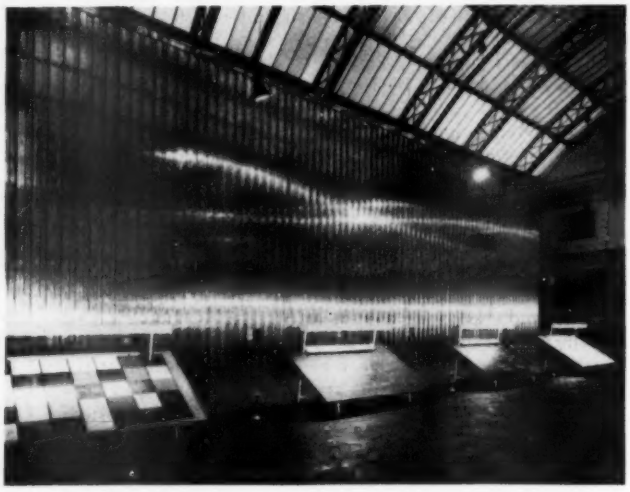
Substantial quantities of the Type 2 atmospheric corrosion-resistant grade have been used for building panels, roof decking, silo roofs, air conditioning enclosures, rolling door sections, corrugated industrial roofing and welded tubing.

Summary

Aluminium-coated steel is well suited to a wide range of applications where the requirements are superior heat and corrosion resistance, good heat reflectivity and strength at elevated temperatures. Standard production methods can be used in the fabrication and welding of these sheets. Maximum service temperature for Type 1 is several hundred degrees higher than allowable with zinc coatings, and the corrosion life of Type 2 is estimated at least three times that of 1 oz./sq. ft. galvanized sheet in industrial atmospheres. Aluminium-coated steel has a strength and economic advantage over solid aluminium of the same thickness, and the steel base usually permits a reduction in thickness. A major increase in use of this product is indicated by a recent trend towards its much wider use in automobile exhaust systems.

Exhibition of Aluminium Cladding for Buildings

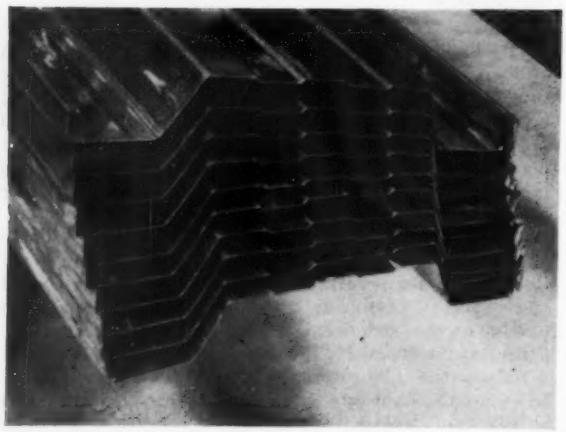
Rigidal Seamwall on Show



The 30 ft. high × 90 ft. long wall in Rigidal Seamwall.

THE suitability of unpainted aluminium for the exterior covering of buildings in a wide range of atmospheres has been established beyond doubt by numerous post-war applications, backed by the longer experience of the classic pre-war applications, some of which are now more than fifty years old. The highlight of a recent exhibition, organised by The British Aluminium Co., Ltd., and held at the Old Horticultural Hall in Westminster, was a 30 ft. high × 90 ft. long wall in the new Rigidal Seamwall cladding. Detailed displays showed fixings to different types of wall and sheeting rail, the use of insulated linings, and the treatment of door and window openings ; sample panels showed the range of finishes in which the material is available. In addition to the Seamwall display, Rigidal corrugated sheeting in the standard profiles and finishes was on show.

Rigidal Seamwall was designed by the Development Department of The British Aluminium Co., Ltd., specifically as a wall cladding having a bold profile particularly suitable for large buildings : it is made in B.A. 60 alloy (B.S. 1470 : NS3). The shape of the new product can be seen from the illustration, from which it will be noted that there is a single upstand at one edge of the panel and a double one at the other. The effective width of the panels is 12 in. and the standard thicknesses are 20 s.w.g. and 19 s.w.g. Normally they are supplied in lengths up to 40 ft. but longer panels may be obtained by special arrangement. Plain or stucco embossed finishes are available, and both can be supplied with Alocrom 100 surface treatment in lengths up to 16 ft.



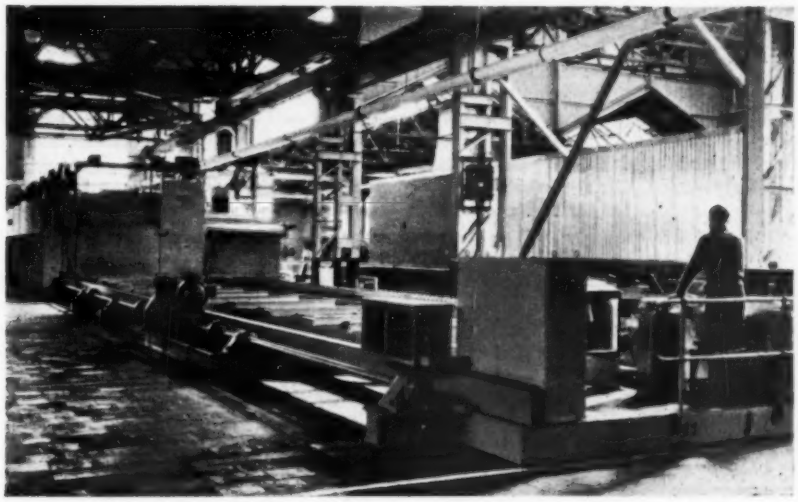
A pile of Seamwall panels showing the shape of the section.

Where concealed fixing is required, a simple clip is placed over the single upstand of the panel and secured to the sheeting rail. The double upstand of the adjacent panel, containing the appropriate caulking compound, is then pressed home over it, and the seam joints completed by a series of button punch dimples. Seamwall is not intended for roof coverings, because the seam joint, although satisfactory for walls, could not be relied upon for weatherproofing sloping roof surfaces.

It is claimed for Seamwall that the scale and profile are such as to maintain texture and shadow values of large expanses of wall cladding. Furthermore, its availability in lengths up to 40 ft. enables end laps to be avoided.

Either concealed fastening or traditional sheet fastening methods may be used, and the joints are completely sealed by the built-in caulking material. Finally, Seamwall may be used in conjunction with standard insulating materials where thermal or fire insulation is specified.

Intermediate Annealing of Aluminium
New Plate Furnace Installation



General view of the 65-ft. furnace with cooling chamber on right and charging machine in the foreground.

FOR the past two-and-a half years, the Northern Aluminium Co., Ltd., have been carrying out a large scale development programme involving the introduction of much new plant and handling equipment. Included in this programme was the installation of a new batch type furnace, designed and erected by G.W.B. Furnaces, Ltd., at the Banbury Works, which produces a wide range of sheets, coils and discs, both in aluminium and a variety of aluminium alloys. Previously the mills engaged in rolling aluminium sheet could roll a maximum width of 5 ft. ; now the new mills can produce widths of up to 6 ft. 6 in. and the G.W.B. furnace has been specially designed to fit in with this new development. In hot rolling 8-in. thick ingots of aluminium down to approximately 0·3–0·5 in., some work hardening takes place, and consequently annealing is necessary before cold rolling to lighter gauges : the material treated in the new furnace is normally of the heavy duty type used in aircraft, coachwork, decorative finishes, motor car trim, etc. The furnace can accommodate loads up to 16 tons for lengths of 65 ft. and widths of 6 ft. 6 in. ; and the maximum temperature is 600° C., although normal operating temperatures are somewhat lower. The furnace has a rating of 1,000 kW. arranged in six independent and automatically controlled zones, of equal length, distributed as follows : Zone 1—220 kW., Zones 2 to 5—150 kW. each, Zone 6—180 kW. The high rating enables cycle times of as low as 4 hours to be achieved : a three-shift system is at present being worked.

The heating chamber is lined throughout with heat-resisting alloy, backed by a thick wall of Moler insulating bricks, thus reducing heat losses to a minimum. The furnace body is constructed from sheet mild steel casing braced with mild steel rolled sections, and fitted with a mild steel front plate. A robust understructure supports the furnace clear of the ground, and permits free air circulation under the hearth. A cast-framed, refractory-faced, fully-insulated and counterbalanced door, driven by electric motor, minimises heat losses at the furnace entrance. Heating elements of high grade nickel-chromium strip, arranged on removable plugs, are situated in the roof of the chamber, and each zone is fitted with a forced air circulation system directed cross flow from the fan, through the heating elements contained in the ducted portion of the heating chamber, down into the treatment chamber, and back into the fan for recirculation. A double-cased baffle of heat-resisting alloy, packed with a layer of insulation, is fitted in the roof of the chamber, separating the heating elements from the actual working area, thus preventing radiation on to the charge. The elements are suspended edge-on to the air stream between the roof and the insulated baffle by a hook suspension method, ensuring maximum support and preventing "element flutter." On each side of the working chamber a system of equally spaced and parallel baffles extends fully down the length of the chamber. Each baffle is independently adjustable to direct the air flow in such a manner as to give the desired flow characteristics and equalise the temperature throughout the working chamber. A section of the insulated fan scroll is removable to facilitate inspection of both the heating elements and the fan unit. Six air circulating fans are fitted (one per zone) and each fan is capable of delivering 30,000 cu. ft. of air per minute. Each unit comprises a statically and dynamically balanced centrifugal fan mounted on a high-tensile steel shaft, carried in a robust cast bearing bracket fitted to the cross bracings of the roof of the furnace casing. The bearing bracket is fitted with dual purpose ball and roller bearings, and provided with oil seals in the base of the unit, while a heat dissipating rotor is fitted to the shaft

immediately above the furnace casing to reduce the bearing temperature. The fan shaft is driven through adjustable vee ropes by an independent totally enclosed electric motor. Each fan unit may be withdrawn through the side of the furnace casing.

With heat-treatable alloys, in order to obtain fully-annealed material, a slow cool is essential. To ensure this, a cooling chamber, similar in size to the heating chamber, has been incorporated in the installation. The cooling chamber comprises a rigidly constructed framework fabricated from rolled steel sections covered with non-combustible asbestos panels. The door is of the roll-up, flexible-slat type, with electrical drive and push-button control. Six fan units are again provided, one per zone, with the necessary ducting to direct the air flow into the chamber. A splitter plate is arranged in the roof of the chamber so that the air flow is directed down one side of the chamber, through the charge, and then back up into the fan eyelets for recirculation.

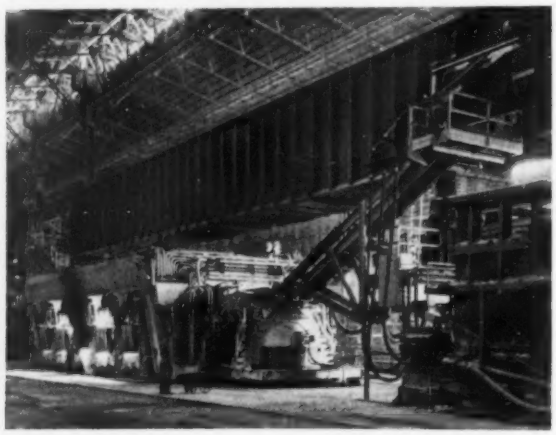
A G.W.B. single track charging machine serves both the furnace and the cooling chamber. It is designed to work in conjunction with the roller fitted charge skips. The machine is of very heavy construction, being mounted upon three rows of rail wheels for traversing, and a "go-getter" facilitates charging and discharging. The overall length of the furnace and charging machine is approximately 160 ft.

Temperature control in such processes is critical, and this is provided automatically through a G.W.B. instrument cubicle. Six Integra, Leeds and Northrup indicating controllers are provided (one for each zone) and a six-point recording instrument allows a positive visual check on thermal conditions throughout the process cycle. A Venner 15-day automatic time switch is incorporated in the panel, together with six green lamp bezels indicating which element zones are on and one red lamp bezel labelled "Equipment Alive." The switchgear is contained in a separate G.W.B. contactor cubicle and comprises six furnace zone triple pole contactors, six fan motor contactors and one door drive motor contactor. Adequate protective devices are incorporated: safety contacts are arranged to cut off the supply to the heating elements in the event of accidental overheating; a limit switch is fitted to the furnace door, cutting off the supply to the heating elements when the door is in the raised position; and one Ellison oil immersed circuit breaker allows the whole installation to be rendered "dead."

Second "Ajax" Furnace Conversion at Appleby-Frodingham

THE second open-hearth furnace at Appleby-Frodingham Steel Company, Scunthorpe, to be converted to the Ajax oxygen process made a record output of 4,254 ingot tons during its first operating week, beginning its first charge on the morning of Sunday, June 7th. This was 912 tons more than its previous best for a full week, and is also a record for the company's Appleby melting shop. Lit by Lt.-Cdr. G. W. Wells, managing director (production) of the United Steel Cos., Ltd., and director and general manager of Appleby-Frodingham, the furnace retains its original hearth with an area of 526 sq. ft. and is tapping an average of 180 tons per tap from charges consisting of 100% phosphoric pig iron produced entirely from home ores.

Combined output of the newly-converted furnace and the original Ajax furnace, on which trials began in February, 1958, is expected to be about 9,000 tons per week, with an average fuel consumption of under 10 therms per ton. The lowest consumption figure achieved for a week's production on the earlier furnace was 7·10 therms per ton; the highest weekly output was 5,717 tons. Actual output from the two furnaces during the first week in which they were in operation totalled 9,406 tons.



The second open-hearth furnace to be converted to the Ajax oxygen process at Appleby-Frodingham.

Modification of an open-hearth furnace to the Ajax process developed at Appleby-Frodingham enables a material increase in ingot production to be attained at a capital cost which is only a fraction of that necessary to instal any of the other oxygen steelmaking processes. The changeover can be made in four to eight weeks, the actual time depending largely on the mechanical handling facilities available for the conversion in the melting shop. The first Ajax furnace took 26 days from "gas out" to "gas in"; the second required eight weeks, because it is in the middle of a busy shop and also because it was found that some of the concrete foundation work under the furnace rockers needed replacing.

UNDER the Statute of the Royal Society which provides for the election of persons who either have rendered conspicuous service to the cause of science or are such that their election would be of signal benefit to the Society, His Majesty King Gustaf VI Adolf of Sweden has been elected a Fellow.

WILD-BARFIELD ELECTRIC FURNACES, LTD. have received an order from the Mond Nickel Co., Ltd., for a Wild-Barfield NRC induction heated vacuum melting furnace having a capacity of 112 lb. of nickel-base alloys. The furnace, which is to be used for the production of experimental alloys, will be powered by a B.T.H. 125 kW., vertical spindle type generator.

NEWS AND ANNOUNCEMENTS

Special Courses in Metallurgy

FIVE special evening courses in subjects of metallurgical interest have been arranged for the coming session by the Metallurgy Section of the Department of Engineering in the Kingston Technical College. They are: Chemistry and Metallurgy of the Rarer Metals—eight lectures given by specialists from industry, commencing Tuesday, October 20th, 1959; Principles of Corrosion and Protection of Metals—eight lectures given by Mr. G. Isserlis, commencing Thursday, October 22nd, 1959; Metallurgy and Semi-Conductor Devices—six lectures given by Mr. A. S. Abrahams, commencing Thursday, January 5th, 1960; Corrosion Problems in the Aircraft Industry—six lectures given by specialists from industry, commencing Tuesday, February 16th, 1960; and Technology of Copper-Base Alloys—six lectures given by specialists from industry, commencing Thursday, February 18th, 1960. Further particulars may be obtained from the College, Fassett Road, Kingston-upon-Thames, Surrey.

Mond Nickel Exhibition

AN interesting feature of the recent Mond Nickel Company exhibition at the Cutlers' Hall, Sheffield, was a working model of a rhodium plating plant, which was specially designed for the exhibition. Rhodium is a bright, untarnishable metal with high reflectivity, and is frequently used for the plating of headlamps, searchlights, etc. One of the platinum group of metals, rhodium is refined by the Inco-Mond organisation, which, in addition to being the world's largest nickel producer, is responsible for nearly half the platinum metals produced outside the Soviet bloc.

The exhibition, which was well attended by industrialists, technologists and students in the Sheffield area, was designed to demonstrate the properties of nickel, nickel-containing materials, the platinum metals and spheroidal graphite cast iron. Apart from what may be termed nickel alloys, nickel is one of the most widely used alloying elements, finding applications in both the ferrous and non-ferrous fields, and the fact that it is used to enhance low, normal, and high temperature mechanical properties; to confer particular magnetic properties; to produce corrosion and heat-resistant alloys; to produce spheroidal graphite cast iron; and as an electrodeposit—among other things—gives some idea of the task involved in staging an exhibition of this type. That the task was successfully accomplished was evident to those who visited the Cutlers' Hall.

Welding Technology Courses

FOUR courses in varied aspects of welding, organised by the School of Welding Technology, will be held during September and October. Course D 17—Advanced Course for Welding Engineers—which is to be held from September 22nd to 30th, is designed to provide, at an advanced level, the latest information and views, both from this country and abroad, on a wide range of topics of interest and importance to welding engineers. The second course, D 1/2, will deal with welded design and construction of pressure vessels and pipework, and will be held from October 12th to 16th. The remaining two courses, D 12/1—Control of Distortion—and D 13/1—Residual Stresses and Stress Relief—have been arranged for October 26th to 28th and October 29th to 30th October, respectively. Further particulars may be obtained from the Institute of Welding, 54 Princes Gate, Exhibition Road, London, S.W.7.

Spark Machining Symposium

ORGANISED by the National Association of Drop Forgers and Stampers, a one-day symposium dealing with spark machining as a means of die sinking will be held at the Botanical Gardens, Birmingham, on Wednesday, September 16th. Further details and application form for registration may be obtained from the Technical Officer, Mr. G. H. Jackson, National Association of Drop Forgers and Stampers, Grove Hill House, 245, Grove Lane, Handsworth, Birmingham, 20.

I.C.I.-Alcoa Agreement

IMPERIAL CHEMICAL INDUSTRIES, LTD. has entered into an agreement with the Aluminum Company of America (Alcoa) to collaborate in the manufacture of wrought aluminium products. The two companies propose, the consent of H.M. Treasury having been obtained, to establish a new company, to be registered as Imperial Aluminium Co., Ltd., to which I.C.I.'s aluminium plant at Waunarlwydd will be transferred, and which will manufacture the wrought aluminium products now being sold by I.C.I. and any others it is subsequently decided to produce. Initially at least, these products will be sold through the existing I.C.I. selling offices.

I.C.I. will hold 51% and Alcoa 49% of the capital of the new company, and I.C.I. will appoint three of the five directors, including the Chairman and Managing Director: control will, therefore, remain in British hands. At the same time the accumulated experience and technical resources of Alcoa will be available to the new company, which, apart from a limited number of technical staff on secondment from Alcoa, will employ U.K. staff and workers.

Stal in English

IN recent years, growing interest has been shown in the technological developments within the Soviet Union. In the field of iron and steelmaking, Russian scientists and engineers have been responsible for many important technical advances, but details of these are not readily available except in Russian. By arrangement with the Department of Scientific and Industrial Research, the Iron and Steel Institute is undertaking the monthly publication of a complete English-language version of *Stal* (Steel), the major Russian periodical in the sphere of iron and steelmaking technology, in which many of the more significant developments are reported.

The January issue of *Stal in English* has recently been published, and is obtainable from the Iron and Steel Institute. The subscription rate for twelve monthly issues is £20 (plus 12s. postage), and the cost of single copies £2 (plus 1s. postage). Special rates are available

for members of the Institute, and a discount of 16⅔% on the published price will be allowed to libraries of Universities and technical colleges if orders are placed directly with the Institute.

Work Study Courses

A SERIES of short courses in work study and allied management subjects has been organised by the Department of Industrial Engineering at Loughborough College of Technology, and will be held in the Autumn Term, 1959. Selection for admission to courses depends upon potentialities for obtaining benefit from them, and it is suggested that sponsoring companies should select for entry those who have the requisite personal qualities and sufficient initial technical knowledge, and who are familiar with the processes and practices in their own fields of activity. Further particulars can be obtained from the Department of Industrial Engineering at the College.

Titanium Prices Reduced

THE largest reductions so far made in the price of British wrought titanium products were announced by the Metals Division of Imperial Chemical Industries, Ltd., at the beginning of June. The heaviest cuts are in prices for sheet, strip, plate and wire, which are reduced by 25%; rod and billet prices are cut by 15% and extrusions (latest addition to the range of I.C.I. wrought titanium products) by 12½%. These reductions—the second in twelve months—bring the price of I.C.I. wrought titanium to less than half the level operating in 1955, when the Company started commercial production.

High Speed Photography Committee

THE aims of the National Committee for High Speed Photography which has recently been formed, in association with the Royal Photographic Society, are to provide a representative national body for dealing with international matters in this field; to organise one-day conferences in Great Britain; to stimulate and to co-ordinate publication; and to assist in abstracting and disseminating information on the subject.

The first National Conference, to be held at Queen Mary College, London, E.1, on September 18th, will have as its theme the application of high speed photography to industrial problems such as welding, glass fracture, and combustion. The Secretary to the Committee, Dr. R. F. Saxe, of Queen Mary College, would be pleased to hear from anyone interested in the Conference or in matters relating to high speed photography.

Creep Information Centre

IN response to requests from manufacturers and users of high-temperature materials, a Creep Information Centre is being set up at the National Engineering Laboratory (formerly the Mechanical Engineering Research Laboratory) at East Kilbride, so that industrial designers can more readily obtain data on the strength of high-temperature materials. All interested organisations are invited to co-operate in supplying experimental data so that the scheme may become as effective as possible.

The main object of the Centre will be to collect and tabulate all the available data on creep and rupture properties of conventional high-temperature materials. Data for British materials will be issued in an agreed form as far as considerations of commercial security allow. The scheme will later be extended to include fatigue and other mechanical properties of high-temperature materials and information about test procedures and testing machines; data on foreign materials may also be included.

A leaflet giving further details of the scope of the Creep Information Centre is available from the Laboratory. All firms and research organisations concerned with the production or use of high-temperature engineering materials are invited to participate, and to write to the Director, National Engineering Laboratory, East Kilbride, Glasgow.

Beryllium Production in U.K.

IMPERIAL SMELTING CORPORATION, the U.K. subsidiary of Consolidated Zinc Corporation, and the Beryllium Corporation of Reading, Pa., U.S.A., announce the formation—subject to Exchange Control consent—of a new, equally-owned British company, Consolidated Beryllium, Ltd., which Imperial Smelting will manage. The new company will produce nuclear grade beryllium metal and beryllium-copper master alloy as raw materials for sale to fabricators, both in the U.K. and in Europe. It will operate the beryllium metal plant now under construction at Avonmouth and due to start production later this year, and will commence immediately the erection of a beryllium-copper master alloy plant at Avonmouth to supply an already established market for this material in the U.K.—to which the Beryllium Corporation has been exporting for more than a decade. In view of the possible future requirements of beryllium metal for use in the U.K. nuclear power reactor programme, the new company is planning the largest beryllium metal plant in the world, to enable construction to begin without delay as soon as a large scale demand develops.

D.S.I.R. Technical Digests

THE Department of Scientific and Industrial Research devotes considerable effort to helping industry—especially the smaller units—to bridge gaps in scientific "know-how," and as a means to this end, D.S.I.R. Technical Digests—which proved so popular during an experimental try-out two years ago—have returned to the field of available literature. Each month, there will be issued fifteen items describing new ideas and new techniques which have appeared in British technical periodicals. To ensure efficient distribution within a firm, each item is presented on a separate sheet. The annual subscription is three guineas, with a reduction for quantity supplies.

Coke Oven Contract

WOODALL-DUCKHAM CONSTRUCTION CO., LTD. has been entrusted with an important contract by Colvilles, Ltd., to build a complete coke oven and by-product plant costing about £2¼ million. This is in connection with the next stage of the developments at Ravenscraig and will be the fourth complete coke oven installation built for Colvilles.

RECENT DEVELOPMENTS
MATERIALS : PROCESSES : EQUIPMENT

M.I.C.8. Tool Steel

THE Tool Steel Department of English Steel Rolling Mills Corporation, Ltd., is producing in increasing quantities a graphitic type tool steel. Known as M.I.C.8., it is an oil hardened tool steel having freedom from distortion in heat treatment equal to that of conventional carbon-manganese non-distorting steels. It is quite different, however, from these conventional steels in that it features a higher carbon content, and by careful control of the analysis and metallurgical conditions of processing, a portion of the carbon is retained in the final product in the form of graphite particles uniformly dispersed throughout the structure.

The graphite particles act as a lubricant and considerably improve its machinability. They also reduce the tendency to seize, gall, or score induced by the rubbing of metal against the surface of the tool. These unique properties, combined with its uniform response to heat treatment and good hardenability, make it ideally suited for components of intricate shape which have to withstand wear and abrasion. It is produced as rolled or forged bar, forged blanks and rings.

Tool Steel Department, English Steel Rolling Mills Corporation, Ltd., Openshaw, Manchester.

Mechanical Lubricator

A NEW mechanical lubricator, known as the DP 60, is announced by C. C. Wakefield and Co., Ltd.; it can be supplied in a range of sizes to give from 1–32 feeds. This unit, which replaces the DP 50, feeds oil at a pre-determined rate and in pre-determined quantity to the frictional surfaces of a machine.

The lubricator is normally actuated by the machine being lubricated, and the oil supply, therefore, automatically commences and ceases with the movement of the machine. The human element is thus kept to a minimum and efficient lubrication is combined with economy in oil consumption. Two particular advantages are claimed for the DP 60:

(a) The usual sight feed glass which withstands pressures up to 600 lb./sq. in. is replaced by a Perspex tube and metal shroud capable of withstanding 2,000 lb./sq. in.

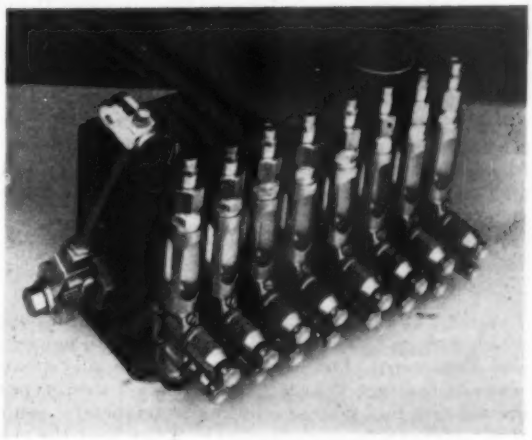
(b) The oil reservoir is of welded steel construction which, in an eight feed lubricator, effects a weight saving of as much as 29 lb. over the usual cast iron type of reservoir.

Additional features of the lubricator are:

(1) Each feed can be regulated from zero to maximum by a regulator screw at the front of the corresponding pump unit.

(2) Each feed has a separate flushing plunger operating independently of the pump plunger; full flushing feed can therefore be obtained irrespective of the position of the pump plunger.

(3) An air vent screw is provided to each feed to disperse air locks should they occur when pumping commences.



(4) Each pump unit can be removed and replaced in one assembly.

(5) A Perspex oil level gauge is built into the side of the reservoir.

The new lubricator is eminently suitable for both steam and internal combustion engines, and can be readily applied for the forced feed lubrication of all types of pumps, compressors, crushers, cranes, gas works plant, excavators, exhausters, conveyor chains, bakery plant, oven chains, presses, pulverizers, winders, calenders, paper making plant and industrial machinery generally.

C. C. Wakefield and Co., Ltd., 46 Grosvenor Street, London, W.1.

Furnace Atmosphere Control

FOXBORO-YOXALL now supplies a self-contained cabinet, fully piped and wired, incorporating record and control functions and providing a precise method of controlling furnace atmospheres, based on the simple relationship between dewpoint and carbon potential. The unit is eminently suitable for atmosphere control on a wide range of heat treatment processes, including gas carburising, carbonitriding and bright annealing.

In operation, a gas sample of about 20/30 cu. ft./hr. is drawn from the generator or furnace, and led via a cooling coil into a sample chamber in which a Dewcel is mounted. The whole of this assembly rests in a cooling bath filled with water. For dewpoints above 12° F. (low carbon potentials) running mains water is adequate to lower the sample temperature to within the Dewcel operating range. For dewpoints down to −5° F. (high carbon potentials) the bath requires refrigeration to lower the sample temperature to about 35° F. Lower dewpoints can be measured by the installation of a compressor in the sample line which has the effect of elevating the dewpoint and makes measurement practical down to −40° F. atmospheric pressure base.

The Foxboro Dewcel humidity sensitive cell consists essentially of a thermometer bulb inside a thin walled

metal tube covered with a woven glass tape which is impregnated with a hygroscopic salt. Two parallel gold wires, connected to a 25 V. A.C. supply, are wound over the tape, and the whole is protected by a perforated metal guard. When the salt absorbs moisture from the surrounding atmosphere it becomes an electrical conductor and current passes between the two wires, thereby raising the Dewcel temperature until equilibrium is reached. This equilibrium temperature is measured by a liquid expansion thermometer or a resistance bulb, and is recorded as dewpoint.

Where control is fitted, a proportional plus reset controller is used to operate a pneumatic control valve which alters the air/gas ratio to the generator, or, in the case of propane enrichment at the furnace, throttles a valve in the propane line.

Foxboro-Yoxall, Ltd., Redhill, Surrey

Plastic Plating Barrel

THE EPE 12 totally immersed cylindrical plating barrel which has just been introduced by Sonic Engineering and Equipment, Ltd., is made from specially treated, abrasion resistant Perspex. It is resistant to all types of pre-cleaning and plating solutions at temperatures up to 80°C., and can be used effectively throughout the entire cleaning and plating cycle, thus eliminating a great deal of handling. In operation, the barrel is placed on the cathode rod and on one anode rod in the plating tank, and current is fed through leads from the cathode rod connection to cathode contacts inside the barrel. A fractional horsepower motor mounted at the top of the frame to rotate the barrel can operate either on mains current or on 6 V. or 12 V. D.C. supply from the busbar or the anode circuit.

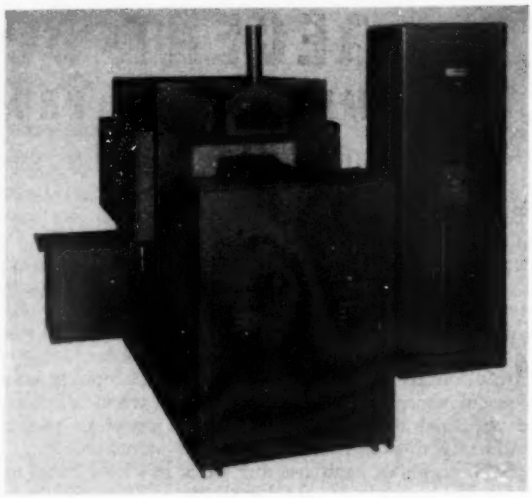
The barrel is suitably perforated so that the smallest sized parts can be properly processed, and is fitted with a quick release lid for loading and unloading. A high grade polythene version of the unit can be supplied for use with solutions at temperatures above 80°C.—such as electroless nickel—while a hexagonal barrel can be provided if required. The overall length of the barrel is 12 in. and the diameter 6 in., with a recommended process load of 10–12 lb. The EPE 8, a smaller version, is also available, in which the barrel length is reduced to 8 in.

The barrel units are fitted with tumbling strips and can be supplied individually or with whatever types of tank are required, such as single plating units, or complete cleaning, plating and rinsing installations for large scale production. Parts which can be successfully plated in this type of barrel include safety pins, rivets, nails, all types of screws, bolts, nuts, washers and other small components. The barrel is also particularly suitable for use in the plating of precious metals.

Sonic Engineering and Equipment, Ltd., 120–130 Parchmore Road, Thornton Heath, Surrey.

Shaker Hearth Furnace

THE shaker hearth furnace, arranged to be used with artificial atmospheres, is extremely useful for the bright hardening of carbon steels, and the bright annealing of ferrous and non-ferrous metals, such as pressings, stampings and machine parts. The shaker movement in the new Hedin furnace prevents flat components from jumping on top of one another, thus obviating inconsistency of heat treatment. The charge passing through the furnace can be regulated according to its weight and



nature by an infinitely variable speed unit. Further, the arrangement of the elements can be adjusted to suit varying weights of charge, and care has been taken to prevent the cooling, even of the lightest charge, whilst it is on its way to the quench.

The hearth is of cast nickel-chromium, and can either be machined perfectly smooth or grooved to suit individual requirements. It is housed in a gas-tight heat resisting muffle, and is fitted with a water-cooled shute where it enters the oil quench to prevent heat conduction to the oil. The illustration shows a standard model rated at 18 kW. and capable of treating 50 lb./hr. The plant is supplied with a floor mounted cubicle housing the electrical control gear. The quench tank can either be supplied fitted with work baskets, or mechanised to bring the charge out of the quench.

Hedin, Ltd., Commerce Estate, South Woodford, London, E.18.

Aluminium Foil Posters

FOR the first time in Britain, aluminium foil posters have been printed and posted, having their first "public appearance" in the Newcastle area recently. Originated by Mr. Matt Millar, P.R.O., of the Star Aluminium Co., Ltd., of Wolverhampton, they represent an important advance in poster technique.

Many problems had to be faced, including the difficulty of pasting the posters on hoardings, as foil is impervious to water. This was overcome by the use of a perforated foil specially produced for the purpose, which enabled normal drying to take place and a firm adhesion to be secured. Priestley Studios of Gloucester co-operated in the printing, silk screening the colours in light lettering on a black background to secure a maximum of visibility.

The potentialities opened up by the use of foil posters are considerable: the natural properties of aluminium foil make them attractive to the eye; they stand out conspicuously among other posters; and they are far more weather-resistant. These first posters were printed in four colours, but there is obviously no limit to the number of colours in which they can be produced.

Star Aluminium Co., Ltd., Marston Road, Wolverhampton.

LABORATORY METHODS
MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC
INSTRUMENTS AND MATERIALS

JULY, 1959. Vol. LX, No. 35

The Analysis of Nickel

Part I—Chemical Methods

By T. R. Andrew and C. H. R. Gentry

Material Research Laboratory, The Mullard Radio Valve Co., Ltd., Mitcham Junction.

A critical survey is given of published methods for the chemical determination of the alloying constituents and impurities in electronic nickel. On the basis of a re-examination of the published methods and additional investigations, specific methods for each element have been formulated. Detailed instructions are provided for carrying out the several methods with statements of the time required and the precision attainable under routine conditions. Several of the methods, which are mainly photometric, are original, and all should be applicable to other non-ferrous metals in addition to nickel.

IN the radio valve industry, the efficient manufacture of reliable valves and tubes is dependent upon careful control of the composition of the "electronic nickel" which is extensively used for the construction of cathodes, anodes and other component parts. The term "electronic nickel" is used to designate pure nickel or low-alloy nickels with compositions within the range given in Table 1. This table also shows a typical analysis of an "O" grade valve cathode nickel which is widely used at the present time. Other compositions, including tungsten-containing nickels, at present find specialised use or are of experimental interest. In the future, other alloys are expected to be widely used, containing only one or two desirable elements, but otherwise extremely pure.

TABLE 1.—COMPOSITION RANGE OF ELECTRONIC NICKEL

Element	Range %	Composition of Typical Cathode Nickel %
Aluminium	0·001–0·1	0·01
Carbon	0·001–0·1	0·02
Chromium	0·03 max.	trace
Cobalt	0·01–1	0·05
Copper	0·005–0·2	0·01
Iron	0·005–0·2	0·07
Magnesium	0·001–0·1	0·07
Manganese	0·001–0·2	0·02
Phosphorus	0·02 max.	0·001
Silicon	0·001–0·3	0·03
Sulphur	0·01 max.	0·002
Titanium	0·001–0·05	0·01
Tungsten	4 max.	absent
Zinc	0·01 max.	absent

It is worth noting that almost all the constituents listed have some influence, good or bad, on the behaviour of the nickel in the vacuum device. Thus, in cathode nickel, aluminium, carbon and magnesium are responsible for reactions which give rise to the electron emission; chromium, silicon, sulphur and titanium may be responsible for reactions which are detrimental to the electron emission; copper, magnesium, manganese and zinc may evaporate and degrade the insulation, or otherwise impair the properties of the valve; tungsten is a deliberate additive which improves the strength of the cathode; even cobalt and iron, which are without significant influence on the behaviour of the material, are sometimes of interest in tagging a particular batch of nickel.

It can be seen that the analytical problem is a not inconsiderable one, and one that is frequently aggravated in practice by limitations on the amount of available sample. Hence, although most of the methods to be given require a sample weight of either 0·1 or 0·25 g., they have been designed so that they can be adapted to samples weighing only 10 mg. by suitable choice of aliquot or final volume of solution.

For routine control purposes, the analysis of electronic nickel is preferably carried out spectrographically, and suitable methods for this will be given as Part II of this paper by G. P. Mitchell and G. Orme. The present paper is concerned with chemical methods which might be used for referee purposes, for occasional determination of an element not normally analysed spectrographically, or in laboratories where spectrographic facilities are not available. Although the methods have been developed particularly for electronic nickel, they are obviously equally applicable to nickel used for other purposes, for example in electroplating or in the chemical, food or electrical industries. They are also often applicable to nickel-rich alloys generally.

In the present paper, each of the elements listed in Table I will be considered in turn. In each case, after a brief survey of the literature, an indication will be given of the methods tried, which have led to the one preferred. This will be described in detail, with a note of any possible interferences, the time required for a determination, and a realistic appraisal of the accuracy based on replicate determinations on a range of samples analysed under routine conditions. It is, perhaps, worth noting here that almost all of the methods given have also been tried out in other associated laboratories.

In accordance with modern practice, almost all of the preferred methods are photometric, and it is convenient to make a number of general observations on these methods here. In accepting a method, an important criterion has been its operational simplicity, although this

TABLE II.—PREFERRED VALUES FOR SAMPLES USED IN EVALUATING PROCEDURES. (MOND NICKEL COMPANY'S NICKEL-BASE SPECTROGRAPHIC SUB-STANDARDS).

Element (%)	Sample					
	A	B	C	D	E	F
Aluminium	0·009	0·013	0·019	0·050	0·070	0·098
Chromium	0·010	0·015	0·024	0·049	0·083	0·125
Cobalt ..	0·055	0·28	1·04	0·58	0·14	0·037
Copper ..	0·014	0·023	0·053	0·054	0·44	0·23
Iron ..	0·50	0·25	0·090	0·057	0·034	0·049
Magnesium	0·213	0·107	0·049	0·023	0·015	0·009
Manganese ..	0·018	0·027	0·058	0·112	0·24	0·47
Silicon ..	0·235	0·42	0·18	0·145	0·095	0·015
Titanium ..	0·010	0·015	0·026	0·044	0·080	0·112

very simplicity has often required much more development work than if a more obvious method had been used, involving, perhaps, preliminary separations of the element sought or of some interfering elements. The simplicity of the method patently leads to greater economy and reliability when the procedure is applied on a day-to-day basis; less apparent, but nevertheless equally important, is the advantage of greater accuracy which frequently follows, even in referee determinations. Properly designed photometric methods are, in the present authors' view, inherently more accurate than methods which adopt the classical approach of using a large sample weight and involve such stages as mercury cathode electrolysis and group separations, before an eventual volumetric or gravimetric finish. For this to be the case, however, it is essential that the operationally-simple method be found and due attention given to the problem of the blank determination. As can be seen from the lower limits given in Table I, this is a more serious problem than in the rather similar case of steel analysis. In this paper, where the blank is particularly important, instructions are included as to the methods advocated for its correction.

Another problem frequently encountered in photometric analysis is the preparation of the calibration graph. If a supply of the main constituent, in this case nickel, is available of sufficient purity or of known composition, then it is a comparatively simple matter to prepare a series of synthetic standard sample solutions on which the calibration graph can be based. However, it is not always a simple matter to obtain the main constituent in a state of sufficient purity or of known composition. In some cases, this difficulty can be overcome by omitting the main constituent from the standardising solutions, provided that it has been established that it is without effect on the final colour measured. In this paper, detailed instructions on the preparation of the calibration graphs will not be given, since the procedures involved can readily be deduced by anyone acquainted with photometric techniques, but the standard substance recommended for preparing the calibration graphs will be given, as well as a statement on the necessity for adding pure nickel or not.

All the methods have been developed using a spectrophotometer (Unicam SP500), but are intended generally for use with a filter photometer (such as the Spekker absorptiometer). The instructions will, therefore, include both the wavelength of measurement and suitable filters for use with a tungsten filament or mercury lamp.

For testing the methods advocated, synthetic solutions have been used containing in many cases the possible interfering elements at the highest concentrations liable to be met in practice. For confirmation of the absence of any interferences, a series of standard nickel samples has been used. This series, for the use of which we are indebted to Henry Wiggin and Co., Ltd., and the Mond Nickel Co., Ltd., covered an even wider range of constituents than the requirements listed in Table I. The standards have been analysed by a number of laboratories, using both chemical methods (frequently different from those advocated in this paper) and spectrographic techniques. The preferred values for these standard samples are given in Table II. Replicate analyses of them have served to establish the precision of the methods, and the agreement of the average values obtained with the preferred values has provided good evidence of the accuracy of the methods.

Aluminium

The methods usually proposed for the determination of aluminium in nickel require large samples and a preliminary separation of interfering elements. Thus, Inco[1] utilise mercury cathode electrolysis to remove nickel and other heavy metals, followed by cupferron precipitation from sulphuric acid solution to remove titanium. Conditions are then adjusted to permit the precipitation of aluminium with cupferron, and the final determination is made gravimetrically after precipitation as the phosphate. Davis and Holton,[4] after a prior separation of the hydrous oxides, make a mercury cathode electrolysis to remove any contaminating nickel, chromium and manganese, then separate titanium with cupferron, and eventually weigh the aluminium as the ignited oxide. The A.S.T.M.[2] have adopted mercury cathode electrolysis, followed by a chloroform extraction of cupferrates and final photometric determination with aluminon. Serfass and Levine[5] have proposed a method for traces of aluminium in nickel plating baths in which iron is removed by extraction with cupferron and amyl acetate, nickel is removed by chloroform extraction of the diethyldithiocarbamate, and the aluminium finally determined with aluminon.

The present authors have tried most of these methods and, although the results have been acceptable, the time required has been longer than considered desirable. Good results have also been obtained with the Eriochromecyanine R photometric procedure of Hill,[6] but, although this method is substantially specific for aluminium, it is still necessary to separate the bulk of the nickel by mercury cathode electrolysis in order to maintain a reasonably low level of background colour.

Eriochromecyanine R is probably the best of the several lake-forming reagents commonly used for determining small amounts of aluminium. However, none of these reactions is particularly attractive, since all require very close control of conditions if good results are to be obtained, and all are subject to numerous interferences. Many of them also suffer from a high blank value. For these reasons, the photometric determination of aluminium by extraction of the 8-hydroxyquinolate into chloroform[7] has been preferred by a number of workers.

Some years ago, a method of overcoming many of the interferences with the 8-hydroxyquinoline procedure by forming cyanide complexes was put forward from this Laboratory.[8] This has since been in regular use, without any difficulties being found, for the determination of aluminium in nickel alloys at the 1% level.

Several modifications of the simple cyanide 8-hydroxyquinoline procedure have been proposed in order to minimise the number of potentially interfering elements,

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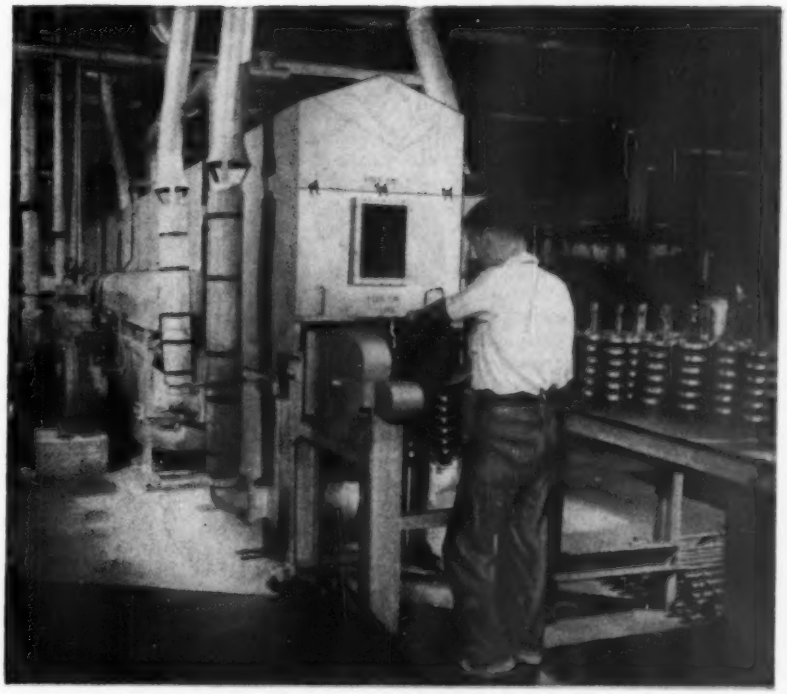

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but these are generally limited in scope or markedly more complex than the original procedure. Thus, the highly selective procedure of Claassen *et al.*[9] has been used by us for the determination of aluminium in electronic nickel, but the method is tedious and requires a fair degree of skill and experience if satisfactory results are to be obtained. It has also been found essential to modify the published conditions slightly ; for example by extending the time for the back extraction of the initial 8-hydroxyquinoline extract into 2 N hydrochloric acid from the 1 minute advocated to at least 2 minutes.

The two elements which may be present in electronic nickel which were only briefly studied in the original work of Gentry and Sherrington,[8] and which represent potential interferences, are manganese and titanium. Yokosoka[10] has proposed a method for determining aluminium in nickel by extracting the 8-hydroxyquinolate complex into benzene at *p*H 9 in the presence of cyanide and tartrate. The method is said to be subject to interference from manganese if above 0·02%. For nickel containing more than this amount of manganese, an alternative procedure is proposed, using a photometric determination of aluminium after mercury cathode electrolysis. No reference is made to the effect of titanium, if present.

The work of Gardner[11] on the extraction of a " peroxidised " form of titanium oxinate suggested the possibility of a procedure which would enable both titanium and aluminium to be determined together by measurement of the optical density of the 8-hydroxyquinoline extracts containing the titanium complex in the normal and then the " peroxidised " form. We have shown this to be possible for pure aluminium and titanium solutions, but it is inadequate for the precise determination of small amounts of aluminium in the presence of much larger quantities of titanium.

A procedure proposed by Motojima and Hashitani[12] advocated prior separation of titanium by extraction with 8-hydroxyquinaldine at *p*H 5 before determining aluminium by extraction at *p*H 9 with 8-hydroxyquinoline. The authors have had some success with a somewhat similar procedure using an 8-hydroxyquinaldine extraction at *p*H 9 after complexing heavy metals with cyanide, followed by extraction of aluminium with 8-hydroxyquinoline. This procedure closely resembles that of Hynek and Wrangell[13] who, however, use a mercury cathode electrolysis to remove heavy metals rather than utilising complex formation with potassium cyanide.

An examination of the earlier method[8] using oxine extraction in the presence of cyanide showed that no interference is caused by manganese and titanium, but that magnesium in high concentrations (equivalent to > 0·1% in nickel) gives difficulties due to an incomplete and rather variable extraction. To overcome this interference, the use of Complexone III, as proposed by Claassen and his co-workers,[9] has been adopted. In its original form this technique takes rather a long time, since the rate of formation of the aluminium oxinate is markedly retarded in the presence of Complexone III, even when using much smaller amounts than recommended by Claassen *et al.* To get over this difficulty, we have adopted a procedure in which the aluminium and part of the magnesium is extracted into the chloroform layer, and the Complexone III is then added to the aqueous phase and the whole re-shaken to remove any magnesium from the organic layer. It would also be possible to separate the chloroform layer containing the aluminium and part of the magnesium, and then to wash it with a buffered solution containing Complexone III. The adopted procedure, however, has the advantage of a lower blank.

In its final form, the complete method is as follows :—

Dissolve 50 mg. sample in 2 ml. dilute nitric acid (1 : 1), dilute to approximately 30 ml. and boil gently for 5 minutes, cool and add dilute ammonia (1 : 1) until the blue nickel ammine is formed. Add 5 ml. 15% potassium cyanide and warm to 50° C. Add 5 ml. 10% sodium sulphide and stand 3 minutes. Add 2g. solid ammonium sulphate and transfer to a separating funnel. Dilute to 50 ± 5 ml. and shake for 3 minutes with 10·0 ml. 1% 8-hydroxyquinoline in chloroform. Add 5 ml. 0·05% ethylenediaminetetra-acetic acid (disodium salt) and shake for a further 3 minutes. Allow the layers to separate and run off the lower layer into a clean, dry beaker containing *ca.* 1g. anhydrous sodium sulphate. Swirl gently and record the optical density at 400 mμ in 1 cm. cells. A filter instrument may be used with a mercury vapour lamp H503 and Ilford 601 filters. A blank must be carried through the procedure. If the magnesium content is known to be low (<0·05%), the first extract may be used without further treatment. The range of the method is 0·001–0·1% aluminium.

For standardising the method, solutions prepared from pure aluminium should be used. The presence of nickel is not essential, and the use of the complexing agents may, if desired, be omitted, provided that the extraction is carried out from a solution of *p*H 10 ± 0·5.

The method is rapid as compared with most of the other published methods ; six samples may be analysed in less than three hours. As applied to electronic nickel, the procedure is specific for aluminium. This has been shown both with pure solutions and by analysis of the Mond Nickel Company's standards. On these standards, the coefficient of variation was ±2·0%.

Carbon

The techniques which may be applied to the determination of carbon in nickel are so closely allied to those used in steel analysis that it is not proposed to consider them at any length. Provided that a sufficiently high temperature is available for the initial combustion, the selection of the final measuring procedure is restricted only by the range and precision required. For nickel, Inco[1] and A.S.T.M.[2] advocate combustion with a gravimetric finish, while for electronic nickel, A.S.T.M.[3] recommend a low pressure method. The authors would advocate the conductometric procedure of Chirnside *et al.*[14] as being most suitable for general use, with a furnace temperature of 1,300° C. and a copper flux.

Chromium

The only published method for the determination of chromium in electronic nickel, of which the authors are aware, is that of Luke.[15] Luke states that the determination of chromium without prior separation of nickel was found impracticable, and describes a procedure involving separation of copper with dithizone, and of nickel, cobalt, iron, titanium and aluminium with ammonia in the presence of perchlorate. Chromium is oxidised before separation by fuming with perchloric

acid and subsequently completing the oxidation with potassium permanganate. The final determination is made photometrically using diphenylcarbazide.

In these Laboratories, work has been carried out to find a method for the determination of the small amounts of chromium which may be present in electronic nickel without any preliminary separations. Attempts to use the British Standard method for steel analysis,[16] which uses perchloric acid fuming to oxidise the chromium, gave poor recovery at low levels, and this method had to be abandoned. Trials with the bromate oxidation procedure of de Lippa[17] showed promise, and a method was subsequently developed which could be applied without prior separation. No interference was experienced from any of the elements normally present in electronic nickel and, in particular, copper was found to be without effect on the chromium determination, in contrast to the statements of Luke.[15]

Most workers with diphenylcarbazide have experienced non-reproducible calibration graphs, and Allen[18] has recently drawn attention to the apparently forgotten work of Noller[19] on the preparation and purity of this material. Reference to this work revealed that the material commonly available in this country[20] has a melting point well below that of the pure compound. A sample of M.P. 172° C., obtained from Eastman Kodak, Ltd., gave a 20% enhancement of the sensitivity, and values for molar extinction coefficient in good agreement with those quoted by Allen.

This material has been used in the final method, which is as follows :—

> Dissolve 100 mg. sample in 2 ml. nitric acid (1 : 1) and evaporate to moist dryness. Add 25 ml. 0·4 N sulphuric acid and 10 ml. 0·4% potassium bromate. Boil gently for 5 minutes and filter off any precipitate of tungstic acid. Add 10 ml. 20% ammonium sulphate and boil in a covered beaker for 30 minutes, maintaining the volume at 35–40 ml. by addition of small amounts of water. Cool and transfer to a 50 ml. graduated flask and add 5 ml. 5% phenol in 5% acetic acid, followed by 5 ml. 0·25% diphenylcarbazide in acetone. Dilute to mark, mix and read optical density against a water cell at 540 mμ in a 4 cm. cell. For a filter instrument, suitable conditions are a mercury vapour lamp H503 and Ilford 606 filters. A blank should be carried through the method and a suitable correction applied. The range of the method is up to 0·01% chromium.

For samples containing more than 10 μg. chromium, it has been shown that low results are obtained ; possibly due to reduction of the hexavalent chromium by the potassium bromide formed. Accordingly, it is recommended that the sample weight should be chosen to contain 10 μg. chromium or less.

If Eastman Kodak diphenylcarbazide is used, a single calibration graph is usable for many weeks ; with supplies from other manufacturers, the calibration should be checked at frequent intervals. The calibration curve is prepared from a standard dichromate solution added to nickel and carried through the procedure.

Six samples can be analysed in about three hours. The precision of the method is adequate ; on the Mond Nickel Company's standards, with chromium contents below 0·05%, the average deviation from a mean value was 0·001% chromium. Over a range of chromium contents up to 0·14%, a coefficient of variation of ±4% was found.

to be continued

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Platinum-Titanium Electrodes Agreement

IMPERIAL CHEMICAL INDUSTRIES, LTD. and Engelhard Industries, Inc., New Jersey, U.S.A., have signed agreements covering the production and sale of platinum-titanium electrodes. The production of platinum-titanium electrodes by the Metals Division of Imperial Chemical Industries, Ltd., is now well established and has already led to the replacement of those made of materials such as graphite, silicon-iron and lead alloys at present in industrial use. Engelhard Industries Inc. will produce similar electrodes at their U.S. factory.

In addition to its use in the production of chemicals such as chlorine, the new electrode is used for the cathodic protection of steel hulls of ships against corrosion, as well as for bridges, metal piers and industrial plant. Considerable research is also being conducted into the use of such electrodes in electro-dialysis (the conversion of brackish water or sea water to drinking water), electro-descaling, electro-reduction and similar processes. The two organisations will institute a continuing joint research programme and will pool all information acquired.

Kent Course in Spain

THE Customer Training School, normally operated at the Luton headquarters of George Kent, Ltd., has recently been transported to Aviles, on the northern coast of Spain, to train instrument mechanics in the operation and maintenance of Kent instruments, which are extensively employed at the State-sponsored steelworks of Empresa Nacional Siderurgica, S.A. (ENSIDESA). During the five-week period of the course a visit was paid to Aviles by the Kent mobile exhibition, as part of the most extensive tour yet made by this widely travelled " mechanical ambassador." Other industrial centres in Spain, Switzerland, Yugoslavia and Italy are also scheduled for visits.

Stroehlein Furnaces

BECAUSE of recent reductions in import tariffs, furnaces manufactured by Stroehlein & Co. of Düsseldorf—makers of the well-known carbon and simultaneous carbon and sulphur determination apparatus—are now available at reduced prices. Included in the range are single and double tube furnaces with up to four Silit heating rods ; muffle furnaces with Kanthal heating elements for use up to 1,200° C.; and a simple, inexpensive electric crucible-furnace for up to 1,000° C.

Exhibits of Metallurgical Interest at the Physical Society's Exhibition

The exhibits at the Physical Society's annual exhibition of scientific instruments usually include a number of interest to workers in the metallurgical field. This year was no exception, and in this issue we continue a short series of reviews in which such items will be described.

Temperature Display Unit

THE panoramic temperature display unit shown by the Research and Development Department of the Distillers Co., Ltd., displays the outputs of up to 24 thermocouples in the form of a profile on a cathode-ray tube. The 24 thermocouples are scanned successively, vertical displacement of the spot representing the temperature of each in turn, the spot being displaced horizontally by a fixed amount each time a thermocouple is switched in. The display thus consists of a number of vertical lines equally spaced apart in a horizontal direction. The envelope of this pattern represents the temperature distribution at the points at which the thermocouples are located. Scanning of 24 thermocouples takes 1½ seconds.

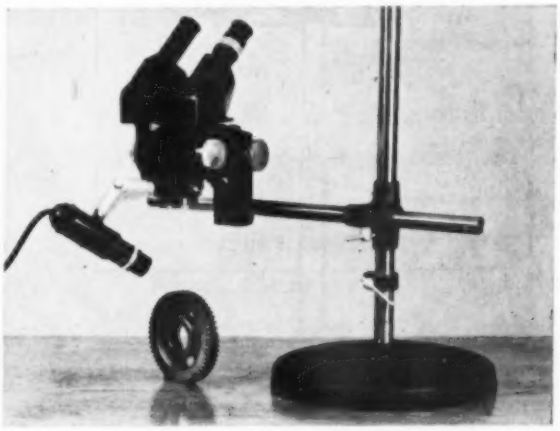
There is provision for backing-off inputs by the same amount, so that a small variation about a high mean temperature may be displayed with a high sensitivity. This feature also permits individual temperatures to be measured. In addition, each input may be backed-off individually so that when a desired temperature distribution is achieved all inputs are effectively zero and a straight line display results. The sensitivity may then be increased so that any deviation from the desired condition may be easily detected. If required, an alarm system may be operated when the deviation exceeds pre-set limits and a set of indicator lamps shows which points have given rise to alarm conditions. Although designed primarily for use with thermocouples, any type of transducer which provides an electrical output signal may be used.

This instrument is not in commercial production, but the exhibitors are prepared to give advice on design to anyone considering building such a device.

Stereoscopic Microscope

The stereoscopic microscope shown by Cooke, Troughton & Simms, Ltd., differs considerably from the conventional form of stereoscopic microscope. Instead of having twin objectives inclined inwards so that their optic axes meet in the plane of the specimen, this new instrument has one objective and an optical system in the body of the microscope to pass left- and right-hand images to the eyepieces to produce the sensation of depth. Thus, the effect is the same as that produced with the more usual type of stereoscopic microscope, but with the advantage that the whole of the field of view is in focus.

The basic microscope body is supported on a fixed pillar and carries an objective of unit magnification. A magnification changer is available to work in conjunction with the three standard eyepiece powers of 10×, 14× and 20×. This enables any one of five different magnifications to be selected for a given objective-eyepiece combination. The total magnification in use is indicated in the window to the side of the changer control.



Courtesy of Cooke, Troughton & Simms, Ltd.

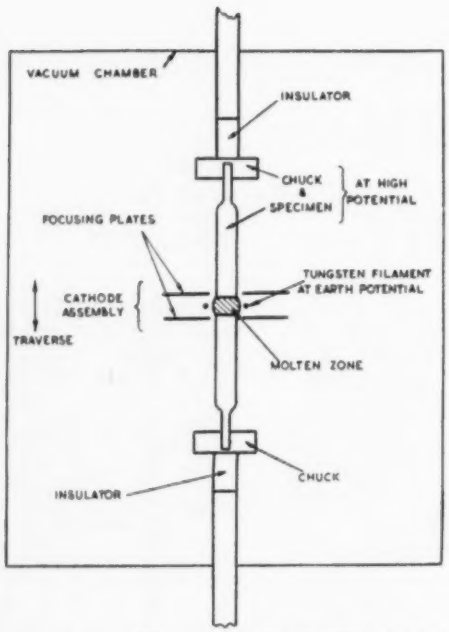
Stereoscopic microscope with illuminator

The illustration shows the microscope with a lamp attached to it. Where incident illumination is required, this lamp may be used in conjunction with a prism attached to the objective mount. The first production models should be available about September and other attachable accessories available will include units for varying the basic magnification of the objective, equipment for using polarised light, a gliding stage, photographic equipment, etc.

Zone Melting

One of the exhibits on the stand of the National Research Development Corporation was an apparatus developed at the Services' Electronics Research Laboratory for the floating zone melting of metals by electron bombardment. This technique has been used for the purification of a wide range of metals by the repeated traversal of a specimen by a molten zone : in this way are segregated at one end of a specimen those impurities which are preferentially soluble in the liquid. Originally, the method of heating was by high-frequency induction or by radiation, but the use of electron bombardment has the advantage that the heat input is highly concentrated, so that the power requirements are small and zone melting of small diameter (0·060 in.) specimens is possible.

The specimen is held vertically between chucks insulated from the case of a vacuum chamber constructed of light alloy plate and fitted with a quartz observation window. The bottom chuck can be raised or lowered during the operation, to allow for closing up or joining when necking or breakage occurs, and to some



Courtesy of the National Decelopment Corporation

Diagram of the zone melting equipment

extent, to control zone shape and length. An oil diffusion pump is used and a liquid nitrogen trap fitted to avoid oil contamination of the specimen. By this means, a vacuum in the 10^{-6}mb. range is attainable, even when considerable outgassing of the specimen takes place. A flap valve enables the chamber to be let down to air while still keeping the vacuum system running..

A ring of 0·020 in. diameter tungsten wire forms the cathode and requires some 40 A. at 6 V. to raise it to emission temperature, the bombarding current being maintained at a steady value, regardless of pressure variations, by a controller varying the heater voltage. The specimen is maintained at a few kilovolts above the potential of the earthed cathode, and the electron beam is focused by means of electrodes operated at cathode potential. The cathode is mounted on an insulated bridge, which can be moved up and down over a 9 in. traverse by means of a rotating lead-screw driven by a servo-controlled motor through a reduction gear system. The apparatus can be operated so that the zone refining cycle is fully automatic. The cathode then traverses the specimen at a slow speed, sweeping the molten zone over a set length, and returning to the start at high speed with the bombarding power set to a low (non-melting) value, when it is ready for the next cycle.

The method is not restricted to the purification of conductors, for, by adding a secondary electrode, insulators such as alumina can also be purified. In its present form, the apparatus is not, however, suitable for refining metals, such as chromium, with extremely high melting point vapour pressure.

Image Intensification

An image intensifier applied to an electron microscope was shown by Siemens Edison Swan, Ltd. This intensifier is placed in the position normally occupied by the fluorescent screen, and consists of a thin stretched plastic membrane which carries the sensitive material (an evaporated layer of amorphous selenium, approximately 15μ thick) as well as the thin (1,000 Å) aluminium signal electrode. The lower surface of the selenium is scanned by an auxiliary electron beam from a low voltage (1,000 V.) gun attached below the instrument. The caster covers an area approximately 2×3 cm. and contains 405 lines scanned at television frequencies. In operation the primary high voltage electrons bearing the electron microscope image penetrate the normally high resistance selenium film and increase its electrical conductivity in accordance with the property of electron bombardment induced conductivity. The differential conductivity over the selenium film is detected by the scanning beam, which stabilizes the surface potential by replacing the leaked charge. The resulting displacement current is passed through a load resistance, and the resulting voltage is amplified and fed to a display tube scanned in synchronism with the image tube.

In theory, the limitation of the device is imposed by electron " noise " in the primary beam, and the performance of the intensifier should equal that of the photographic plate. Results to date include good images on the display tube taken at primary current densities of the order of 10^{-11} A./sq. cm. at 60 kV., at which current density the fluorescent screen in the microscope is just at the limit of visibility.

Corrosion Engineers' Association Formed

At a luncheon given under the auspices of *The Corrosion Engineer* at the Rembrandt Hotel, South Kensington, on May 29th, 1959, Mr. H. M. Powell, who is Technical Director of Cathodic Corrosion Control, Ltd., and Chief Electrical Engineer of the Constructors John Brown organisation, announced the formation of the British Association of Corrosion Engineers. The objects of the Association will be generally to promote the dissemination of technical information about corrosion matters and to develop by means of social activities the free interchange of information among members. In due course the Association, which is essentially non-profit-making, will progress towards the establishment and acceptance of suitable qualifications for corrosion engineers, and the promotion of standardisation in the terminology and techniques of corrosion control. Full details and membership application forms can be obtained from the Hon. Secretary, British Association of Corrosion Engineers, 97 Old Brompton Road, London, S.W.7.

Committee on Fatigue of Structures

A Committee to review current research needs on the fatigue of engineering structures and to survey existing research facilities, has been set up by the Council for Scientific and Industrial Research following an approach from the Institution of Civil Engineers. The Committee will not include aircraft structures, reinforced concrete structures, or metal physics in the scope of its review, though information gained in these fields will be used. The Committee is interested in examining records of failures or accidents which might have been due to structural fatigue, even if fatigue was not recognised as the initial cause. Such information may be helpful in revealing areas in which further research work is needed.

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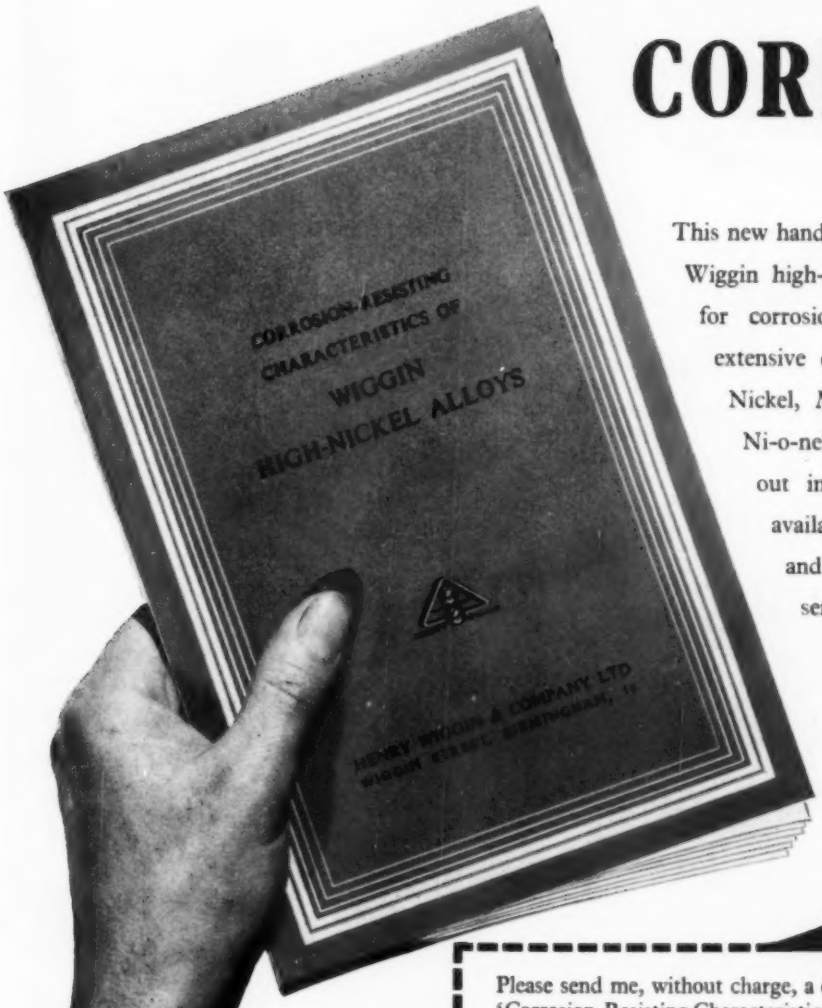

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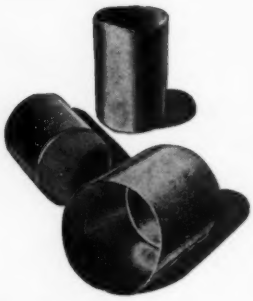

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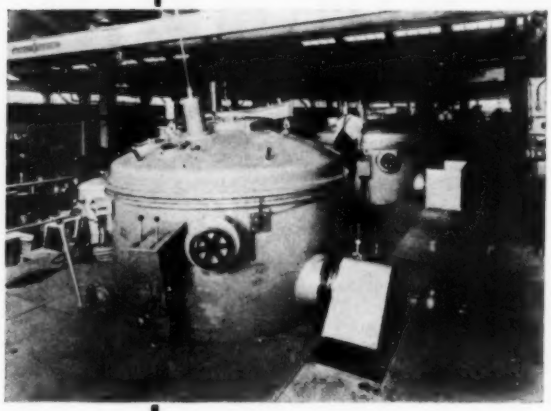

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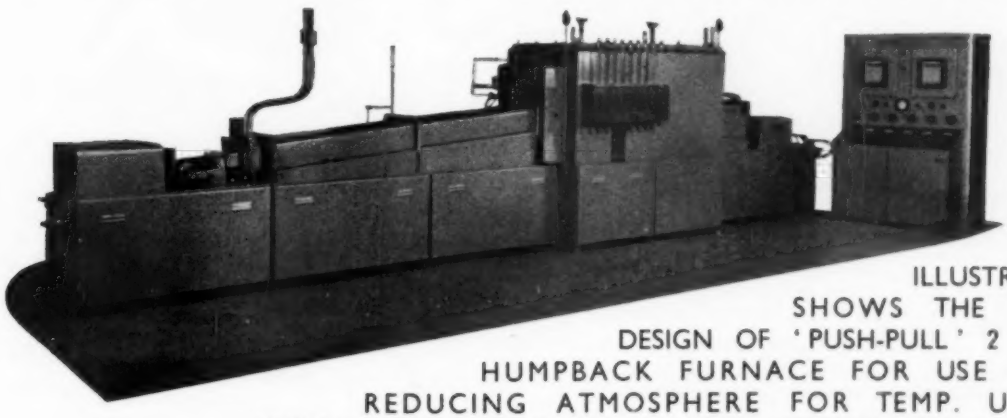

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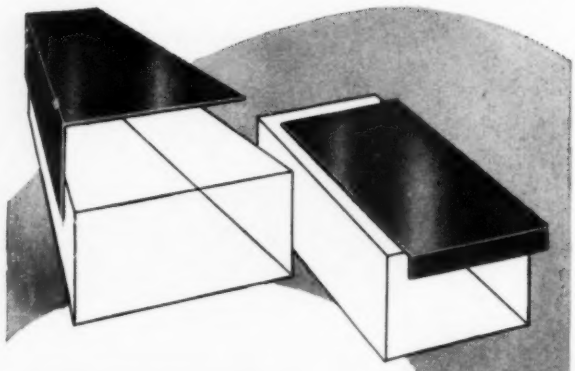

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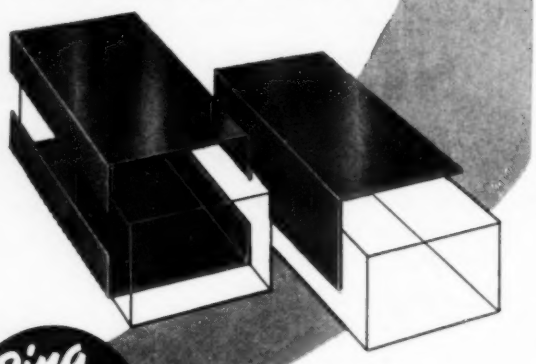

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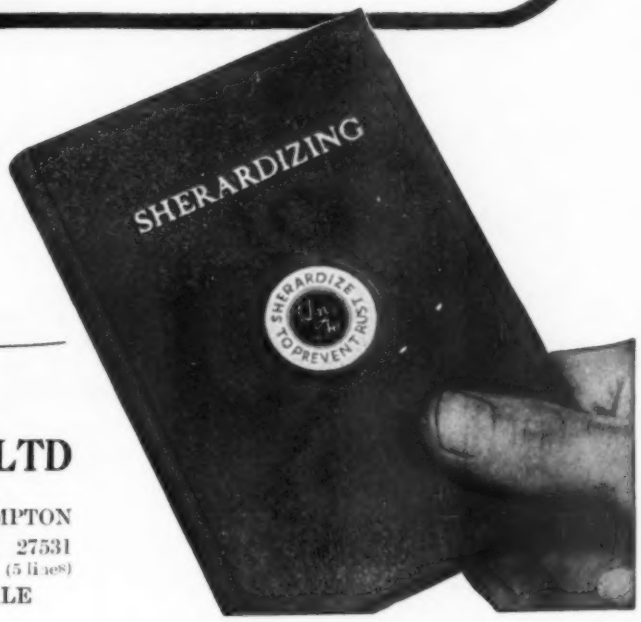

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(*b*) METALLURGIST OR ENGINEER to assist in investigating unusual problems in the testing of metals used in nuclear power stations. Candidates should hold H.N.C. in metallurgy or engineering ; experience in conventional creep and mechanical testing would be an advantage but applicants without this experience will be considered.

Salaries on a scale within the range : £570–£1,300 p.a. according to duties and responsibilities. Ref. M./210.

Application forms obtainable from the Personnel Officer 24/30, Holborn, London, E.C.1., to be returned as soon as possible, quoting relevant reference number.

SITUATIONS VACANT—*continued*

The
BRITISH STEEL CASTINGS RESEARCH ASSOCIATION

The British Steel Castings Research Association, East Bank Road, Sheffield, 2, has the following vacancies for Senior Investigators.

1. *Metallurgy Section*

For long term basic research into factors affecting the deoxidation and desulphurization of steel. The work will include bringing into operation a new vacuum melting furnace and vacuum fusion gas analysis equipment. Previous experience in vacuum techniques would be an advantage but is not essential.

2. *Steelmaking Section*

For research on electric furnace steelmaking involving investigations in the Association's laboratories and development trials and demonstrations on furnaces in foundries.

3. *Foundry Processes Section*

For research on problems relating to the inter-action of molten steel and moulding sands, e.g. sand erosion, metal penetration into sands, novel moulding processes, etc. This post offers the opportunity of training in novel techniques and the investigation of challenging problems marginal to the metallurgical field.

These posts are permanent and superannuable and offer excellent opportunities for advancement. They will be of particular interest to those who wish to carry out original research and to follow through the practical application of the results.

Graduates in metallurgy, with or without post graduate research experience, are invited to write for further information to Dr. A. H. Sully, the Association's Director of Research.

EDWARDS HIGH VACUUM, LTD., Manor Royal, Crawley, Sussex, have vacancies in the Marketing Section of the Sales Department for Technical Sales Assistant and Correspondents. Applicants, who must have a sound general education and a minimum qualification of General Certificate of Education in Physics, General Science or Chemistry and in one case some qualification in Metallurgy, must be able to express themselves concisely and accurately in conversation and writing and have the ability and confidence to promote sales in new and established fields of industry, education and research.

Successful applicants, who will be given full training in the Company's products, will be based at the Company's Head Office in Crawley, but will be required on occasions to make outside visits.

Pensions and Bonus Schemes are operated. Housing available if from London area. Write giving full details of qualifications and experience to the Personnel Manager.

SITUATIONS VACANT—*continued*

NEW ZEALAND DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Vacancy No. 1048

Metallurgist, Dominion Laboratory, Lower Hutt

Duties are : Investigation of causes of service failure in metal equipment (aircraft, power station equipment, etc.) ; determination of physical properties of alloys ; metallurgical research.

Qualifications desired : Degree in Metallurgy or equivalent. Research or industrial experience desirable but not essential.

Salary : Up to £1,485 a year according to qualifications and experience. An outstanding officer may advance to £1,860 a year.

Sea passages for the successful applicant and his wife and children, if any, will be arranged and paid for by the Department. In addition a generous allowance towards the cost of transporting light personal effects will also be granted.

Enquiries mentioning this publication and quoting reference No. B11/21/12 should be addressed to the High Commissioner for New Zealand, 415 Strand, London, W.C.2., who will supply further details and application forms. Completed applications must be lodged in London not later than July 31, 1959.

METALLURGIST as an assistant to the Chief Metallurgist. The work will be connected with the welding of ferrous and non-ferrous alloys, corrosion and general metallurgical problems encountered in the manufacture of plant and equipment for the iron and steel, chemical, oil and gas industries. The company also produces castings in Meehanite and high ductile irons and the appointment will also include work in the foundry for periods as Foundry Metallurgist after suitable training. Applicants should possess A.I.M. or equivalent and be less than 30 years of age. Apply Staff Personnel Manager, Ashmore, Benson Pease & Co., Stockton-on-Tees

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RADIOLOGIST required to take charge of small X-Ray laboratory dealing with examination of light alloy castings. A.I.D. approved man preferred but will consider other experienced applicants. Crystallographic experience an advantage. Superannuation and life assurance. Apply Box No. M.J.61, METALLURGIA, 31, King St. West, Manchester 3.

MIDDLESEX COUNTY COUNCIL

Laboratory Technician required initially at Brunel College of Technology, Woodlands Avenue, Acton, W.3, to assist with maintenance of laboratories and equipment in the Metallurgical Division. Experience of metallurgical work, particularly Metallography desirable. Opportunity for training in this field. Salary : Misc. III—£525–£590, p.a. plus London Weighting. Full particulars to Principal immediately. (Quote Z.813 M.).

CLASSIFIED ADVERTISEMENTS

SITUATIONS VACANT—*continued*

SAND FOUNDRY MANAGER. A progressive well educated man required to take charge of a small light metal foundry in the N.W. Experience in the light metal field involving technical, floor and cost control is essential. A sound working knowledge of modern magnesium alloy casting is preferred. The successful applicant will be expected to travel widely particularly abroad and a knowledge of French or German will therefore be helpful. Age 30–40 years. Salary commensurate with experience and responsibility. Apply Box No. M.J. 62, METALLURGIA, 31,King St. West, Manchester 3.

RUSTON & HORNSBY LIMITED Lincoln, have a vacancy for SENIOR ANALYST in the analytical section of the central metallurgical laboratories of this large engineering works. Applicants must have experience in the latest techniques of analysis for the wide range of materials encountered in an engineering works, including ferrous and non-ferrous metals, solid liquid and gaseous fuels, and of ashes and deposits etc. Salary according to qualifications and experience.

Membership of a generous pension scheme.

Applications from suitably qualified persons, with age and outline of previous experience, should be forwarded to The Manager, Industrial Relations Department.

BRAYSHAW FURNACES LTD., Belle Vue Works, Manchester, 12, request applications for the following positions :—

(a) Designer/Draughtsmen with creative ability and particular knowledge modern furnace design.

(b) Estimator with ability to estimate from Proposal Drawings.

These appointments provide scope for advancement and salary paid will be in accordance with qualifications and experience. The Company works a five day week and a Staff Superannuation Scheme is in operation. Address replies to Secretary, above address.

A VACANCY exists for a Production Metallurgist with a South Yorkshire Foundry. Experience in Metallurgy of Steel essential, and that of Bronze also preferred. Graduate standard necessary. Salary in accordance with experience. Comprehensive Contributory Superannuation Scheme and good working conditions.

Applications giving full details and present salary to Box No. MI 60, METALLURGIA, 31, King St. West, Manchester 3.

SITUATIONS VACANT—*continued*

MIDDLESEX COUNTY COUNCIL
Education Committee
SOUTHALL TECHNICAL COLLEGE

Beaconsfield Road, Southall, Middlesex

Required for September 1st, 1959, or as soon as possible thereafter :—

Lecturer in Metallurgy to teach the subject and some Chemistry in Higher National Diploma and Higher National Certificate courses in Mechanical Engineering. Graduate preferred. Some teaching or industrial experience desirable.

Salary in accordance with the Burnham (Technical) Report within the range (for men), £1,297 16 0d.—£1,467 18 0d. per annum.

Application forms and further particulars (foolscap s.a.e.) from the Principal. Closing date July 17th.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the Education Committee

DIAMOND Compound Manufacturers require experienced Representative/Demonstrator, with sound technical knowledge of all metallurgical applications, polishing and metallography. Driving licence is essential applications for all areas considered. Box M.I. 58, METALLURGIA, 31 King Street West, Manchester 3.

SITUATION WANTED

GRADUATE METALLURGIST, age 27, 5 years industrial experience, seeks position as assistant to Chief Metallurgist of Engineering Company or Consultant Laboratories. South England preferred. Box MJ.63, METALLURGIA, 31, King Street West, Manchester, 3.

SITUATIONS VACANT—*continued*

THERE is a vacancy at the Atomic Weapons Research Establishment, Aldermaston, Berks, for a Metallurgical Process Plant Manager. He will be in charge of a plant in which a high temperature metal is vacuum melted and cast to ingots, processed to powder and vacuum hot-pressed to shape.

Experience in this field is required and a knowledge of casting technique or powder metallurgy technique is desirable together with experience of induction furnace heating and high temperature vacuum technology.

The post will be graded in the Scientific or Experimental Officer class according to the qualifications of the successful applicant. A 1st or 2nd class honours degree in metallurgy, or equivalent qualifications are required for the Scientific Officer class. H.N.C. or equivalent qualifications are required for the Experimental Officer class but a degree would be an advantage.

Salary within the range £675-£1685.

Contributory Superannuation Scheme. A house or substantial assistance with house purchase will become available for married officers living beyond daily travelling distance. POSTCARDS for application forms to the Senior Recruitment Officer, at above address. Please quote reference 2305/126.

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N.H.P. Mounting Plastic, a cold-curing acrylic resin, permits the rapid mounting of metallographic specimens without the aid of heat or pressure.

It calls for the minimum of equipment and skilled attention and yet gives a close, tight mount, capable of a high degree of edge preparation.

Used routinely by many leading manufacturers. Full details on request to the makers: NORTH HILL PLASTICS, LTD. MANLEY COURT, LONDON, N.16.

EDUCATION

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY
SANDWICH COURSE IN METALLURGY

The course is full-time for six months (October to March) followed by six months with the student's firm during which tutorial visits to the College are required. The course of study leads to the award of the Associateship of the College and to A.I.M. Prospectus may be obtained from the Registrar, The Manchester College of Science and Technology, Manchester, 1.

CITY OF SHEFFIELD EDUCATION COMMITTEE
COLLEGE OF TECHNOLOGY
Department of Science

SANDWICH COURSE IN METALLURGY

A three-year Sandwich Course leading to the Higher National Diploma in Metallurgy will commence in September, 1959. In each year of the course students will spend six months full-time in College and six months in industry. For entry to the course the required qualifications will be either a good Ordinary National Certificate in Chemistry or Metallurgy, or appropriate passes at Advanced and Ordinary Levels in the General Certificate of Education.

Full particulars of the course may be obtained from the Registrar, College of Technology, Pond Street, Sheffield, 1.

T. H. TUNN,
Director of Education.

Education Office,
Sheffield, 1.

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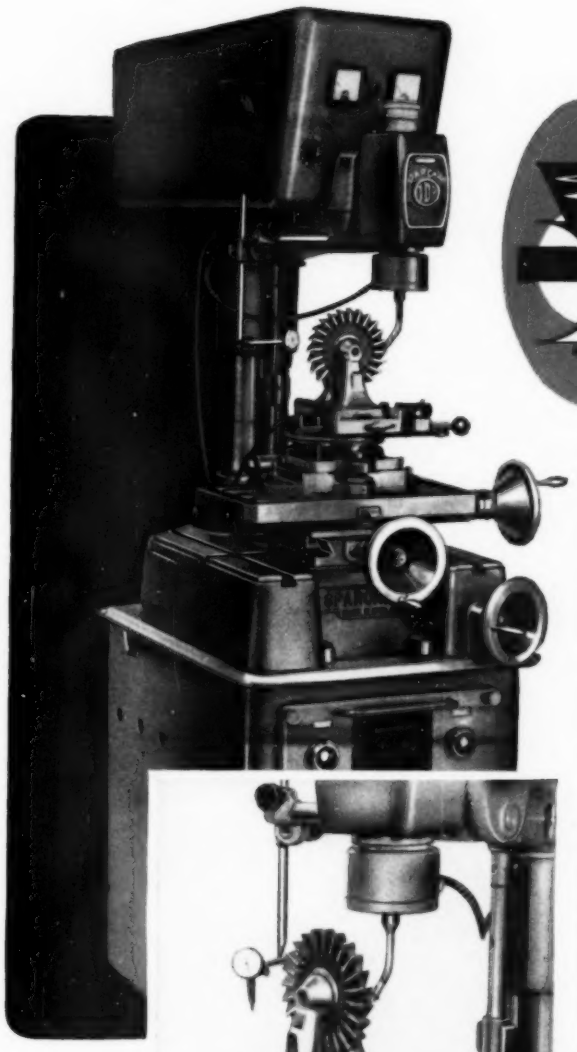

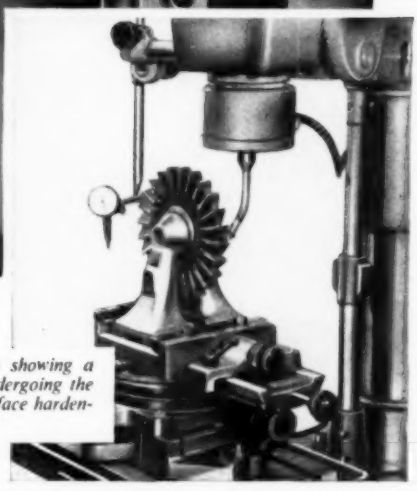

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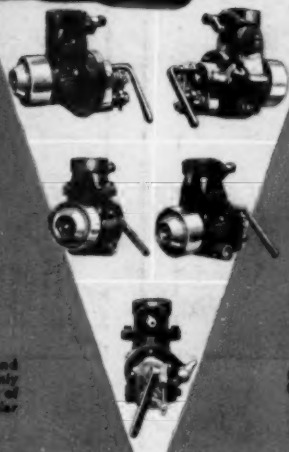

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